POWER PLANT ENGINEERING

Established Over 30 Years

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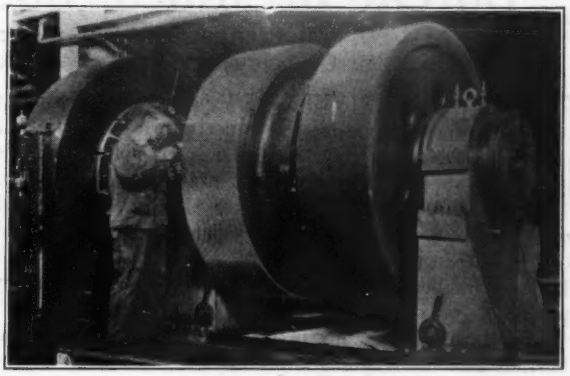


Where One Ten-Thousandth of an Inch Stands Between Success and Failure

FEW THINGS in the manufacture of commercial apparatus require the accuracy necessary in cutting modern large gears. When we consider the great size and weight of some of these large gears and the extreme accuracy with which the teeth are cut, we find the precision of modern manufacturing methods truly amazing. Take the gears shown in the accompanying illustration for instance. This unit which constitutes one of the largest single reduction, herringbone drive gears ever built for a generator, is shown being measured for thickness with a gear tooth vernier. It was built on a special design hobbing machine at the General Electric plant at Lynn, Mass., and will be used in connection with a turbine and generator in a southern papermill.

In cutting this gear the temperature was maintained constant and the machine was kept in continuous operation until the work was finished, as it is impossible to stop the machine while the cutting is being done without affecting the accuracy required for a large gear of this type. The time consumed in cutting was 672 hr. In cutting gears of this class it is necessary to have the journals run true within 0.0005 in., and no limit is allowable in the thickness of the teeth from end to end, as it is necessary to maintain the tooth contact over the entire width of both faces.

This gear has the following specifications: Number of teeth, 296; pitch diameter, 74 in.; outside diameter, 74.410 in.; angle of helix, 35 deg.; width of each cutting face, 20 in.; total width, including space between helixes, 58 in.; estimated weight, 36,000 lb.

Bureau of Mines Aids Power Plant Practice

U. S. Government Station at Pittsburgh Conducts Intensive Research in Combustion, Feed Water Treatment and Refractory Problems*

COMPARATIVELY FEW power plant engineers know or realize the importance of the work of the U. S. Bureau of Mines in fuel research as applied to power plant practice. Besides fuel investigations, which are always being carried on, one of the most important undertakings ever started by the Bureau is now being conducted in co-operation with 17 large public utility companies to investigate refractory problems.

We owe much of our present day knowledge of combustion and power plant engineering to the work of the Bureau of Mines.

Intensive research on fuels in America had its inception in the establishment in 1903 of the U. S. Fuel Testing Plant at the Louisiana Purchase Exposition. Credit must be given to the vision of the late J. A. Holmes, the first director, who in 1910 established the U. S. Bureau of Mines, realizing the great need of fuel conservation in mining and utilization. At the St. Louis World's Fair in 1904, Holmes assembled a group of investigators who began a survey of the fuel resources of the United States. They analyzed, determined the heating value, and tested carload samples of coal and lignite from all parts of the country. The testing included research on combustion, coal washing, briquetting, and gasification. This work is continued today at the Pittsburgh Experiment Station of the Bureau of Mines, where 10,000 samples of coal and lignite are analyzed annually, and research is con-

*Published with approval of Acting Director, U. S. Bureau of Mines.

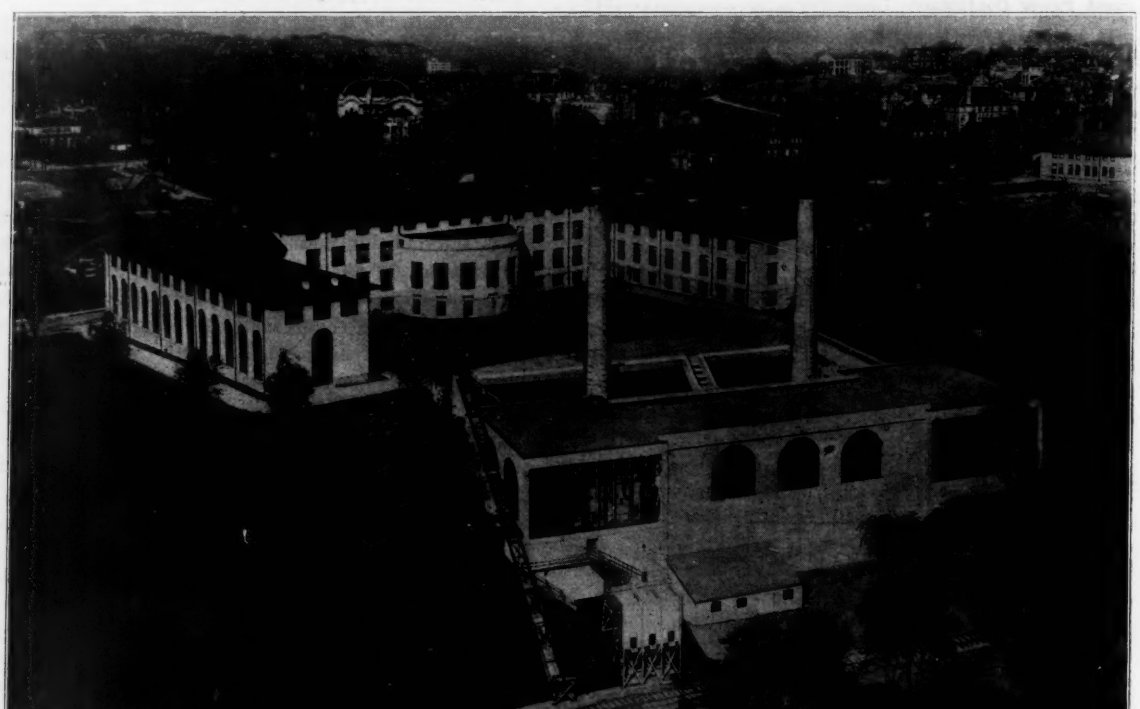


FIG. 1. THIS IS A REAR VIEW OF THE PITTSBURGH STATION WITH ITS OWN POWER PLANT IN THE FOREGROUND

ducted on the mechanism of combustion in boiler furnaces, ceramic kilns, metallurgical furnaces, and house-heating stoves or furnaces, with the object of increasing efficiency and reducing smoke.

The present rapid growth of the burning of pulverized coal in large power plant boilers is the result of organized and deliberate research by engineers in the industry aided by engineers of the Bureau of Mines. Also, the new system of boiler water treatment, now coming into extended application, was developed and perfected at its Pittsburgh Experiment Station. The results of every complete fuel investigation of public interest conducted by this Bureau have been published in the form of bulletins or technical papers.

Research on fuels by the Bureau of Mines was induced by a revival of interest in combustion and the desire for the more economical utilization of fuels at a time when there were few fuel engineers in this country. Its earlier work, therefore, required that it take a prominent part in the testing of installations in the field. Now that there are many highly efficient power plants and engineers and the operators can do and are doing their own research, there is less need for the Bureau to act as formerly, excepting in special cases, and it can devote more time to the study of problems that can be solved in its laboratories.

Scope of Bureau Activities

In the Bureau of Mines is the Division of Fuels, headed by the Chief Mechanical Engineer of the Bureau. The investigations of the Fuels Section are done at Anchorage, Alaska; Pittsburgh, Pa.; Seattle, Wash.; Washington, D. C., and in the field work in Alaska consists of sampling and analyzing coal and problems in its utilization. The Fuels Section does most of its work at Pittsburgh and has a fully equipped laboratory. In close contact with the Fuels Section and directed by the Chief Chemist of the Bureau are the Coal Analysis Laboratory, Coal and Coal Products Laboratory, Microscopic Laboratory, Physical-Chemical Laboratory, Physical Laboratory, and Gas Laboratory. The Division of Fuels has carried on many important investigations with the object of determining the best and most efficient methods of burning the various classes of coal fuels in large power plants, ships, locomotives, boiler plants for heating buildings, and in domestic heating and cooking stoves.

Pittsburgh Experiment Station Has Many Laboratories

At Pittsburgh the Experiment Station of the Bureau of Mines is the greatest institution of its kind in the world. It accounts for 40 per cent of the annual appropriation, 35 per cent of the personnel of the Bureau, and devotes 85 per cent of its energy to problems in coal mining and utilization of coal. The technical staff numbers about 100 men.

Shown in Fig. 1 is a rear view showing the power plant in which are the fuel laboratory, water-tube boilers, high efficiency engines and electric furnaces. Figure 2 is an interior view of the fuel laboratory. None of the equipment shown is permanent—that is to say, when tests with one piece are finished, it may be dismantled for erection of another.

In the coal analysis laboratory shown in Fig. 3, 10,000 samples of coal are ground and analyzed annually. These samples come from coal mines, mine dumps and tipples,

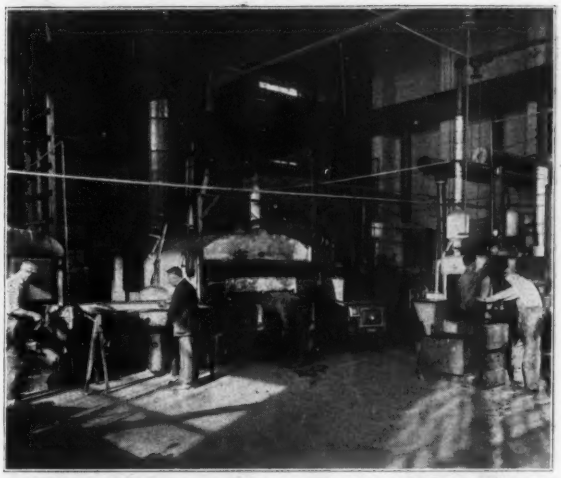


FIG. 2. INTERIOR OF FUEL LABORATORY WHERE PRACTICAL TESTS ARE MADE ON FUEL BURNING EQUIPMENT

railroad cars and docks. The Bureau of Mines has laid down a correct procedure for sampling coal beds and coal piles and this has become standard practice. These analyses are published by the Bureau or jointly with the state concerned.

Figure 4 shows the low temperature carbonization equipment of the Coal and Coal Products Laboratory. The following studies are being investigated by this laboratory: Spontaneous heating and combustion of coal (a source of worry to many power plants), low temperature carbonization of coal and low temperature tars.

Between 300 and 400 samples of gases of all kinds are analyzed each month in the gas laboratory shown in Fig. 5.

Figure 6 shows the physical-chemical laboratory where the problems of boiler water treatment and the prevention of scale and corrosion, described in more detail later, are carried on.

Part of the physical laboratory where materials and instruments, especially pyrometers, used by the Bureau particularly at the Pittsburgh Experiment Station, are calibrated and tested is shown in Fig. 7. The laboratory

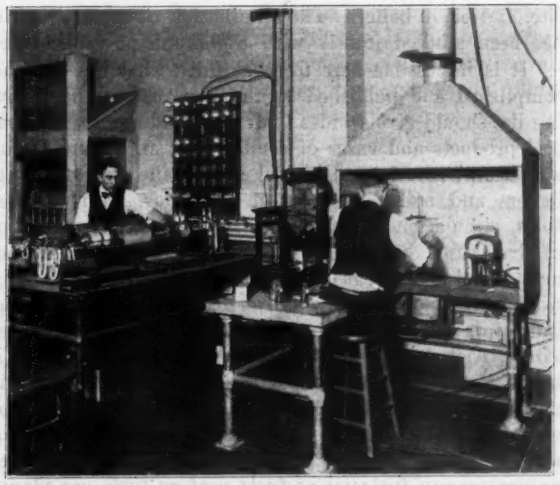


FIG. 3. EVERY YEAR 10,000 SAMPLES OF COAL ARE ANALYZED IN THIS LABORATORY

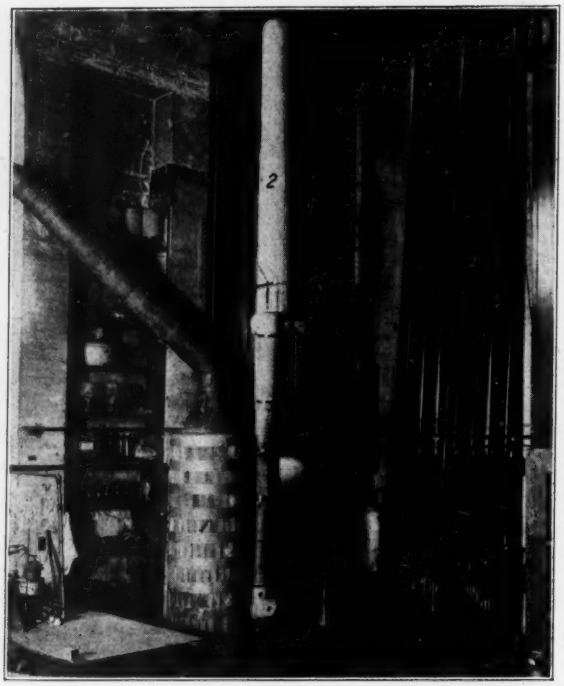


FIG. 4. MUCH OF THE RECENT INFORMATION ON LOW TEMPERATURE CARBONIZATION WAS OBTAINED WITH THIS EQUIPMENT

also acts in a consulting capacity for other Bureau laboratories.

Combustion Problems and Relation to Power Plant Engineering

Fuel testing was the first work of the Pittsburgh Experiment Station and it has been continued here and in large power plants when circumstances justified such cooperation. (Incidentally these studies have included refractories in boiler furnaces and where pulverized coal is used, the Coal Mining Section has investigated the explosion hazards of coal dust.) At the laboratory shown in Fig. 2, tests have included the combustion and utilization of lignite and lignite char, bituminous coal, coke, anthracite, and oil in boilers. The elimination of smoke in cities has been studied jointly with the municipal authorities.

It is impossible here to cover fully what has been accomplished and published by the Bureau, but the following list should give an idea: Methods and analyses of coal, coal products and gases of combustion; anthracite as fuel and steaming tests; ash in coal and its effect on steaming; boilers and boiler furnaces of all kinds, with types of fuels, circulation of water, treatment of water, regulation of draft, fuel bed, combustion, smoke, heat transmission and steaming tests; briquet studies on coal, coke, and lignite; burners for oil and pulverized coal; carbon dioxide indicators; charcoal as gas-producer fuel; coal tests of all kinds; coal dust; coke tests of all kinds; combustion in boiler fuel beds; corrosion of boilers; draft in boiler furnaces; fuels of all kinds; furnaces for boilers, gases of combustion and flue gas tests; gas producers; heat flow and losses; heating boilers and values; lignite as fuel; natural gas as fuel; oil as fuel; peat as fuel; gas plants; producer-gas plants; pulverized coal; sampling fuels and gases of combustion; smoke and its abatement; temperature of boiler metal; volatile matter in fuels; washing coals, and water for boilers.

Fuel Investigations Now in Progress

The investigations under way may be summarized as follows: Heat flow meters for furnace walls. The purpose of this study is to develop heat flow meters for the measurement of heat flow from kiln walls, boiler settings, surfaces of coal in mines, and similar problems. Seven meters have been constructed and calibrated. This work is an illustration of the Bureau's work in developing new or improved methods or instruments for conducting investigations and tests.

Heat Transmission in the Various Sections of a Small House-Heating Boiler. This study is to determine exact losses so that the design of such boilers may be improved and better methods of operation developed. Tests have been made with anthracite, coke, bituminous coal, and natural gas, using various assemblies and modifications of the boiler.

Refractory Service Survey of Boiler Furnaces. This research is supported by a number of large power companies and with technical assistance from a committee appointed by the American Society of Mechanical Engineers. It is expected that this study will enable recommendations to be made as to the best refractory for given furnace and fuel conditions. A general survey has been made of several power plants in the east and central west. Detail studies of furnace conditions and the processes of refractory deterioration are being conducted with the endeavor of associating these with the type of coal burned.

Tests of Cokes Produced by Six Plants Being Tested by the American Gas Association. In this investigation will be determined the characteristics of the coke produced from the same coal by six types of coking furnaces. The physical and chemical properties of these cokes will be measured according to specifications of the American Society for Testing Materials. Standard and special combustibility tests will be made and one on the suitability of the cokes for household furnaces.

Gas Plant Tests in Co-operation with the American Gas Association. At six gas plants, each using similar coal for a month, records will be kept to test the proposed gas

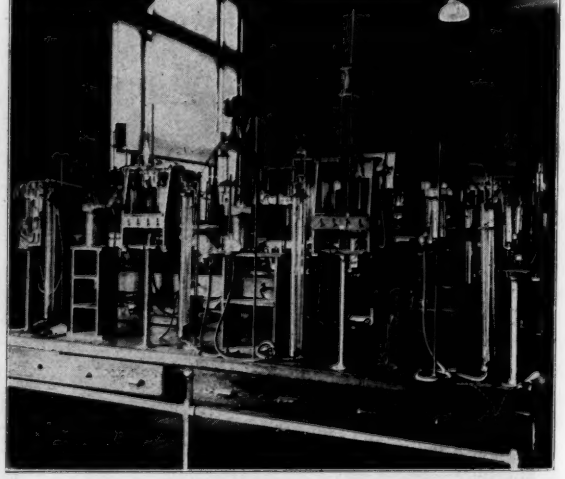


FIG. 5. FURNACE GASES, FUEL GASES (ARTIFICIAL AND NATURAL), MINE AND SEWER GASES ARE ANALYZED WITH THE ORSAT AND HALDANE APPARATUS SHOWN HERE

plant testing code of this Association. The Bureau is co-operating in this work and has completed the test of one plant.

Fusibility of Coal Ash and Formation of Clinker in Boiler Furnaces. This is a joint study with the Consolidated Gas Co. of New York and other companies, and two fellows of Carnegie Institute of Technology have started work. The purpose is to connect clinkering troubles with physical measurements of the coal ash so that the clinkering which will occur with a given coal can be predicted from tests of coal samples. Allied with clinker trouble in the fuel bed is that due to the accumulation of clinker on the boiler tubes.

Boiler Water Conditioning and Corrosion. While not part of the work of the Fuels Section, the research work of the physical-chemical laboratory still under way is of much importance in the matter of combustion and power plant engineering. During the past four years the Bureau of Mines has co-operated with a large corporation in an investigation of boiler water conditioning The principal developments are briefly as follows:

1. Growth of adherent scales is due to deposition *in situ;* that is, the crystals forming their regular structure never exist as separate particles distributed through the boiler water, but grow where found in the scale.

2. Concentration of treating chemical necessary in the boiler water undergoing evaporation to prevent the formation of hard adherent scale is a function of the operating pressure and the sulphate concentration in the boiler water. The chemical may be introduced into the feed or boiler water as desired. Soda ash may be used in general as the treating chemical, but for higher pressures and where greater purity of steam is desired, sodium phosphate is preferable.

3. The necessary concentrations of treating chemical to maintain have been established and simple apparatus has been developed suitable for the control of these concentrations by the boiler operator in the boiler room.

4. It has been proved that it is necessary to provide for the separation of entrained water and insoluble suspended matter from the steam and apparatus for this purpose is sold by the manufacturers.

5. The causes of corrosion in the steam generating and consuming systems have been studied and means pointed out for its inhibition.

6. The results of all laboratory studies have been proved practicable in the number of large power plants.

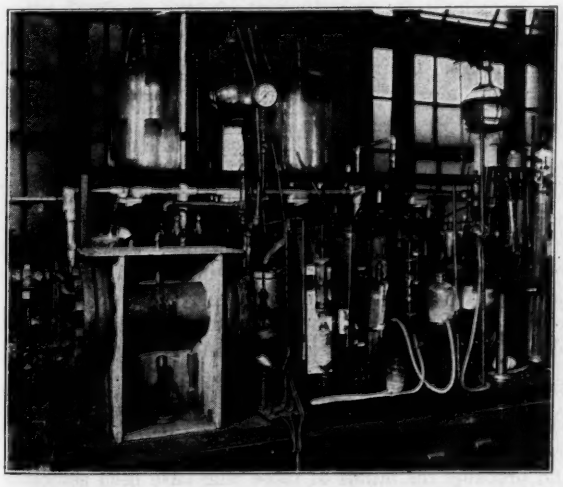


FIG. 6. THIS LABORATORY HAS GIVEN POWER PLANTS IMPORTANT INFORMATION ON BOILER WATER TREATMENT

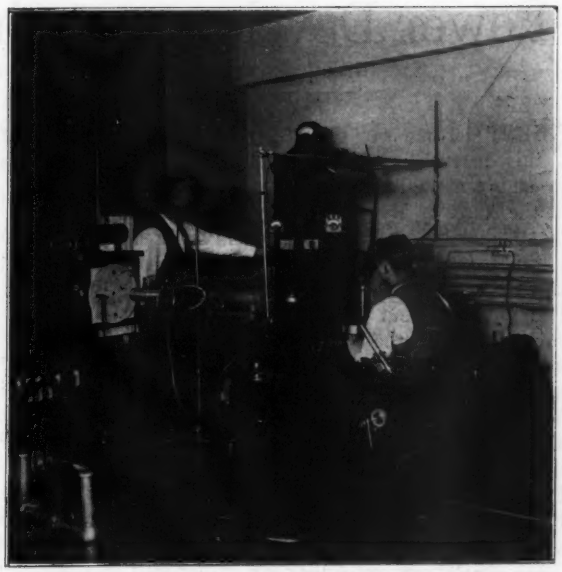


FIG. 7. THERMO-COUPLES AND PYROMETERS USED IN HEAT RESEARCH ARE TESTED HERE

Bureau Follows Both Home and Foreign Practice

Investigations of the U. S. Bureau of Mines into fuels and combustion have been of decided value to the nation and there is every indication that interest in fuel technology will continue to increase in the future. The only drawback is the lag between research and practice. Where direct monetary returns are to be obtained, practice seizes upon the results of research at once, but in the more general field of conservation, in more complete extraction of the coal from the ground and in the elimination of known unsafe practices of mining, and in the adoption of smokeless fuels at a somewhat higher cost, much educational work and direction of operatives remains to be done. Of course, there has been and is close contact with state engineering departments and the engineering profession, and the Bureau of Mines is well informed as to developments in England and Europe, largely by personal visits of its engineers to and by engineers from those countries, and a co-ordination of progress and results follows, beneficial to all concerned.

Plans are being developed for the early consolidation of the Potomac Edison Co., Cumberland, Md., and the Penn-Central Light & Power Co., Altoona, Pa., both of which heretofore have been controlled by the American Water Works Co. The merger will include the extension of present generating facilities and new transmission line construction, with physical connection of the two existing systems at Roxbury, Pa. Power generated at the new steam-operated power plant of the Potomac company at Williamsport, Md., will be made available for service at Altoona. It is proposed to construct a new independent transmission line from Williamsport to Hagerstown. M. F. Riley is president of the Potomac organization, while James C. Jones heads the Penn-Central company.

Power Developments in the Mississippi Valley*

RESOURCES OF THE MIDDLEWEST, DEVELOPMENT OF INTERCONNECTED POWER SYSTEMS, POWER OUTLOOK FOR THE FUTURE. BY SAMUEL INSULL

FIRST let me say something about the resources of this marvelous territory. It includes not only the ten states actually bordering on the Mississippi River, but the states of Michigan, Ohio, Indiana, Alabama, Kansas, Oklahoma and Texas. It covers an area of 1,142,000 sq. mi., or 38 per cent of the total area of the United States. The drainage area of the Mississippi Valley is a little greater, about 1,250,000 sq. mi., the third largest drainage area in the world. Its wealth in 1923 was estimated at $137,000,000,000, or 43 per cent of the total wealth of the United States. Included in the Mississippi Valley is one of the largest, most available and most valuable coal deposits in the world. We produced 53 per cent of the oil, 42 per cent of the lumber, 78 per cent of the cotton, 73 per cent of the corn and oats, and 51 per cent of the wheat and rye, of the total United States production. There are 130,000 mi. of steam railroad within the Mississippi Valley, or 52 per cent of the steam railways of the United States. We have over 50,000,000 people, or about 48 per cent of the population. Agriculturally, it is called the Bread Basket of the World.

The development of this great area is the result largely of geographical conditions. The great Mississippi Valley with the Great Lakes adjacent thereto, the Masaba iron and ore deposits of the North, the Birmingham deposits on the South, the marvelous coal deposits, the rich soil, most favorable climate, wealth untold in forests and other mineral resources. That is the basic condition that we have here. Those are the basic conditions we have here in the Mississippi Valley.

Its power development, excluding the power in use on the farms and the power used by the steam railroads, represents about 37 per cent of the total power operated electrically in the United States. So that, notwithstanding the lower density of population in its territory than that enjoyed by the Eastern Seaboard and the states on the other side of the Allegheny Mountains, our power development comes pretty closely akin to the power development of the more thickly settled states, notwithstanding we have such a wide agricultural area in which electric power has so far been developed to but very small extent. The total power of the United States, excluding farms and steam railroads, is a little over 45,000,000 hp. That of the Mississippi Valley is a little over 17,000,000 hp. The electrically-operated power in the United States is about 34,000,000 hp., or a little more, and that of the Mississippi Valley, about 12,750,000 to 13,000,000 hp., 75 per cent plus, of the power of the whole country, outside of farms and railroads electrically operated, and 74 per cent, plus, of the power in the Mississippi Valley is electrically operated.

Then take the subject of water power. The total potential water power in the whole country, figured as available 50 per cent of the time, with 70 per cent efficiency, is a little over 55,000,000 hp. That is the total available water power in the United States. There is developed about 10,000,000 hp., taking the whole country. Now, the Mississippi Valley has naturally a relatively small amount of that power. The difference in levels being comparatively slight throughout the Mississippi Valley, the amount of power that can be developed is necessarily low. The total possible water power in the Mississippi Valley is about 5,500,000 hp., about 10 per cent of the possible water power available in the United States. Of that amount, 1,750,000 to 1,800,000 has been developed, or a little under 18 per cent of the power of the country, but 32.5 per cent of the possible water power development within the area of the Mississippi Valley.

*Address delivered at the Midwest Power Conference, Jan. 26.

DEVELOPMENT OF THE CENTRAL STATION INDUSTRY

The first central station in the Mississippi Valley was started in the fall of 1882 at Appleton, Wisconsin, within about a month or six weeks of the starting of the first central station operated anywhere in the world for commercial purposes, namely, the old first district in the city of New York. The starting of that plant was preceded by the establishment of numerous arc light plants for street lighting, lighting of public spaces, large public buildings, and dotted throughout the Mississippi Valley there were a number of those arc light companies operating for some years before the light and power central station industry achieved any position of any consequence.

They were followed by the establishment of small central stations in the smaller communities, especially throughout Wisconsin and Illinois and Iowa and Ohio, and it was not until 1888 that the first organized effort in connection with central station electric light and power business was developed here in the city of Chicago. From that time on it developed rapidly. I remember when I came here in 1892, the largest of the numerous companies that gave arc light and incandescent service in the city of Chicago was the old Chicago Arc Light and Power Co.

The next institution of any consequence was the old Chicago Edison Co., of which it was my privilege to be the head. Even that institution was very small. When I first arranged to come here to assume the presidency of that company in the spring of 1892, if my recollection serves me correctly, the total capital invested in the Chicago Edison Co. was $750,000 of capital stock issued and $133,000 of bonds.

There were spread over the city of Chicago and adjacent territory, now taken in as part of the city of Chicago, 20 to 25 different undertakings, different electric undertakings. Their main business was the supply of arc lights, but most of them in 1892 supplied some incandescent service.

But it was well towards the close of the century before the old Chicago Edison Co. and a company of its creation, the Commonwealth Electric Co., afterwards consolidated into the Commonwealth Edison Co., achieved the leadership of the business in this community. It was largely the experience gained here in bringing about the consolidation of these various undertakings that those of us connected with the Edison Co. learned the lesson of the advantages of massing production and arranging for long distance distribution of electrical energy.

Recently I had a volume of speeches looked over and had extracted a number of paragraphs that I think illustrate the development of my own mind on this subject, and probably the minds of those who have been associated with me in the development that we have made in this part of the Mississippi Valley.

I was talking on September 14, 1897, as President of the Association of Edison Illuminating Companies at a convention at Niagara Falls, and in the course of my presidential address I stated: "In studying the methods employed here at Niagara Falls, there is much information that we can take away with us which will lead us to concentrate our works," that is, as central stations, "at the most economical point of production in the various cities in which we live. Further, we can take advantage of the methods of distribution here employed to distribute our product to distant points where we desire to make use of it, and do it far more economically than we can produce it at those distant points themselves."

Just bear in mind that at the time that that address was delivered, it was very seriously discussed whether it was economical to build stations to carry energy over any considerable distance in a city. I remember one very distinguished Scotch engineer, who used to claim at that time, or just before that date, not having in mind the possible use of alternating current, that the given areas from a station should not extend, the network should not extend more than 2500 ft. in any direction, and at that time the old Chicago Edison Co. thought themselves great in achievement when they found that they could get along with the station at Harrison Street and the River, another at Wabash Avenue and 26th Street, another at the Newberry Library, here on the North Side, and another on the Boulevard at 55th Street.

I find in the Western Electrician an article dated September, 1907, on Some Reactions of Central Station Development. I said as follows: "I look forward with confidence to the day when the electric energy required in each of our large cities will be produced under one organization for each city, with a few large generating stations for the production of alternating current, the energy being converted into whatever form may be best adapted for the purpose for which it is required."

Then two years later, in addressing the Association of Edison Illuminating Companies at Briarcliff, New York, on the first of September, 1909, when, if my memory serves me correctly, I was trying to demonstrate to the representatives of the 60 Edison companies there assembled that the wholesaling of energy on a large scale for transportation and industrial purposes was a profitable business, and in the course of that speech I said: "The trend of the times is towards concentration of production. It is inevitable that it must come. Ours is a business which is a natural monopoly. It matters not what the legislation of the moment may be, what the opinions of the politicians may be, what our opinions may be," and I might state, parenthetically, that I knew I had before me in the audience many men who absolutely disagreed with me at that time, "eventually electric energy for a given area must be produced by one concern."

Then in the same speech I stated—that is, in September, on September 1, 1909—"If you are in communities where the business is limited, look out for the next community and get your two properties together. Then try to get still another. And so on, until you have an area that will justify you in building large economical stations. If you do that, when the steam railroads come to consider the question of electrification, when the interurban and urban roads come to consider the matter of increasing their energy requirements, when the manufacturers proceed to enlage their establishments, needing more energy to drive their machinery, then you will be able to quote prices that will give you the business on a basis which will yield you a handsome return and make your securities good in the markets of the world."

You notice there the air of confidence. We were beginning to get results. We had studied the economics of the situation. We had seen the improvement in our load factors. We had discovered the difference in diversity of demand between one business and another, and whereas our efforts were mainly confined to operations within the municipal limits of Chicago, we were laying the basis of that fast development of power, that establishment of a network of transmission lines and distribution system which I will refer to before I sit down, and which will demonstrate to you that this class of service has probably been carried to a greater point, in the Mississippi Valley, than in any other territory in the world.

Now, on May 25, 1910, I was addressing the St. Louis Convention of N.E.L.A., and I described what I considered at that time, with my knowledge of that day—that is, 16 years ago—the function of the electricity supply company, and I stated "You must come to the conclusion,"—I had been presenting them a lot of figures on the subject—"that our true function as central station companies is not only to supply the energy required in the community in which we live, but also to supply the energy required to carry us to the next community." At that time I was urging the electric light and power companies of this part of the country to make an effort to supply energy to the urban and interurban railroads, or in any case, to carry its part of the world. "It seems to me the development upon these lines must in the future inevitably occur. Already we have in the Eastern and Central Western States, with its areas where the extreme distance of territory from one end to the other exceeds 50 or 60 mi. served from one distributing system."

Then take another side of this same subject, its effect on cost and selling price; that is, the concentration of production and the massing of production and the coupling up of distribution systems. This is from a speech delivered at the annual convention of H. M. Byllesby & Co., and affiliated companies on January 18, 1911. "You should have the pumping of the water, the running of the street car lines, the city lighting, the domestic lighting, the running of all the industrial establishments that you may have in your community; in fact, all the possible business in the community, and then after you get that you should go after the business in the next community."

Now I want you to mark this—"and then after you get that, you should go after the business in the next community, 10, 15, 20, or even 25 mi. away, and by further concentration of the manufacture of energy, reduce your cost and consequently, later on, reduce your selling price." In one case we were boastful of an area extending 50 miles from extreme points. A little later on we were urging the operators of central station companies to go even 25 mi. from their plant and try and find business. Now to most of you men here, and fortunately for this great industry, most of the men in it today are still very young men—most of you men here, especially the younger ones, even 15 or 16 yr. of age, could not possibly have had any conception of the vast areas that would be developed, covered from one point of generation in the intervening 15 or 16 yr. I know I had no conception that such a thing would occur.

Then on June 29 of the same year, I think I was addressing a convention of the American Institute of Electrical Engineers in Chicago, I make this extract from

the speech I delivered on that occasion: "By continuing to apply these ideas to the Chicago situation I am rather hopeful of producing and distributing electric energy at the lowest possible price that it can be produced and distributed with steam as the prime mover, and, as a result, to surpass the quantity of production and distribution over that of any other city from one central station company. The success which we have met with in massing the production of energy can, I believe, so far as economy of operation and capital saving is concerned, be greatly exceeded by massing distribution."

Now in that same year, November 1, 1911, I was addressing the employees of the Commonwealth Edison Co., and let me tell you that I would rather address that particular body of employees than any body of men or women anywhere on earth—in talking to my own people, I said that "The lessons that we draw from the work that we have so far done show most clearly that the production and distribution of energy in this great country will be concentrated. Certainly where density of population has reached at all a high point, say from the Atlantic Seaboard to the Mississippi River, the work that we have done in the direction of massing production shows most clearly that the wheels of industry, whether they be on the permanent way of a trunk line railroad or in some great hotel building, like the one we are in, will be turned by the production of energy at a relatively few central points."

I could go on making similar, reading similar extracts all afternoon. I have here before me a great many more of them, and I think with your permission, if I am not detaining you too long, as I have other branches of the subject to deal with, I will just read a few more.

In a speech delivered on March 19, 1913, before the Franklin Institute in Philadelphia, if my recollection serves me correctly, I tried to demonstrate that the taking of a few small central stations, operating in a few villages in Lake County, Illinois, abandoning them, changing their dusk to midnight service to 24-hr. service, and massing the production, the supply of the energy they required, at a point 15 mi. away on the Lake, was the true economic method. Scarcely any effort had been made at that time, less than a decade and a half ago, to give service to the rural districts, to the small villages and to the farmers of a character comparable with the service given in the cities, both as to quality and price. In talking in Philadelphia at the Franklin Institute on the production and distribution of energy on May 19, 1913, I said: "I will endeavor to show you that the true economic method of the production and distribution of energy for all purposes necessarily involves, so far as the statewide service is concerned, concentration of production, concentration of distribution and if you choose to call it so, monopoly of administration of the business of producing and distributing electric energy."

I drew attention on that same occasion to the sociological effect of that policy, in these words: "To my mind there is no more important factor in the great problem of life involving the problem of how the working man can get fresh air and the problem of how he can bring up his family in a healthy locality than the proper solving of the problem of the economical generation and distribution of energy for country districts."

Then a little later—I have always been in the habit of giving my confidences, in the early stages, to my own people, and this was another extract from a speech to the employees of the Commonwealth Edison Co., on May 15, 1913: "It is probably not too bold a prediction to say that within a relatively few years the entire Eastern part of the United States will be covered by a network of electrical transmission and distribution lines; situated in that area at points where the greatest economy of production can be achieved will be large generating stations. The extent of territory that they will serve will depend naturally upon the density of population of the immediate surrounding territory and the relation of cost of energy to interest charges to transmission lines, governed largely by the distance from the source of fuel, namely coal, or the distance from hydroelectric plants, of which large numbers will undoubtedly be erected and prove economical when operated in connection with large distribution systems with steam plants as reserves."

You notice as I have read those extracts, as I stated a little earlier, the tone of approach to the subject has been one of growing and growing confidence, the result of knowledge acquired in the operation of large units of power and the distribution of the product over large areas. Now I pass from that side of the subject. I don't think it is necessary to talk further on that matter, and I will go to some of the statistical portion of the situation, and show you what has occurred in the wonderfully short time of 15 to 16 yr.

Statistics on Present Situation

At the present time 88 per cent of the energy produced in the Mississippi Valley is interconnected. By that I don't mean that it is all in one system. As a matter of fact, there are 14 very large systems in the Mississippi Valley, but they are so closely interconnected that of the total of $525,000,000 of electric energy sold in 1924 in the Valley, over 85 per cent of the energy comes from 14 large different interconnected systems. Only 8.7 per cent comes from municipal plants, and only 6.2 per cent comes from private local plants and groups.

Of the 7,500,000 customers of electric light and power companies in the Mississippi Valley, just below two-thirds of them have the advantage of interconnection of systems. So that we have in this vast territory a very fine example of superpower systems.

The territory of the Mississippi Valley includes the longest transmission interconnection, I think, of anywhere in the world. From the water powers of Central Wisconsin through the great load centers of the Chicago district, down by the mine mouth plants of central Indiana and the Wabash River, and then through southern Indiana to the Ohio River, tying in with the steam station and the water power plant that is now being developed at Louisville, then on south 70 mi. to a high head storage water power of the Dix River, and on through to the mine mouth steam plants established in the high grade coal fields of Virginia, there is a total of over 730 mi. of territory all connected up in one interest. There are other systems in the United States that are connected through, one with the other for a greater distance, in my judgment, but they represent a great many different interests, a great many different financial interests, and I am not sure but what greater credit is due to those systems, because they are an exemplification of the fact that notwithstanding the rivalry in business, notwithstanding the desire of this or that interest to stretch

out and occupy more territory, they all find it a fundamental financial and technical advantage to connect up their systems and operate them, in many cases, as if they were all one ownership.

You have got to remember there are a great many advantages to be obtained in connection with the coupling up of great electric light and power systems. Just take the case that I have spoken to you about—territory extending from Wisconsin to Virginia. Take the diversity in the character of the supply, diversity in the time of the supply leading to a material improvement in load factor, leading to an infinitely greater reliability of service.

Some time within the last year or so there was a case in the South with a number of companies connected up, extending over an area of over 600 miles East and West, from the Atlantic Seaboard practically at the extreme end, either a steam station blew up or a dam went out,—I forget which it was,—each one of those companies, starting 600 miles away, gave up a little of the energy they required for their own service, passed it on to the next one, that one passed that on and a little of his energy, and so they went on from undertaking to undertaking, until when they reached the distant man in trouble, they were able to take care of his entire business, prevent the wheels of industry from shutting down and enabling the workmen and workwomen of that community to go on and do their ordinary work and earn their ordinary daily wage. That is an achievement which is something more than the mere perpetuation of the service so as to get a return on the investment on the part of the company having their money invested in that undertaking. It is of some greater consequence to be able to achieve provision for continuity of service on the part of the whole community and it is of some real value to all these communities, where there is this interconnection of electric light and power systems, to be able to rely on just that situation.

Just let me give you a case of around the city of Chicago.

Naturally, if you want to build a high tension transmission line, either within or around the city of Chicago, there are a great many obstacles. It is not safe to go ahead except on a private right of way. A private right of way costs the power company just about as much money per mile as it costs the steam railroad company. If they want to run a new railroad they have to have about 150 ft. width of right of way. We are gradually building around the city of Chicago high tension transmission lines to carry 100,000 or 150,000 kw., probably 50,000 at the start, later on, 100,000 and 150,000. That will connect up all of our generating stations. It will enable us to a large extent to run our most economical stations at the most economical point of operation. It will enable us to dispense with a very large investment in each of our stations for reserve capacity, because we will have the facility of throwing 50,000 or 100,000 or 150,000 kw. in some generating station in case of disaster. It means lower operating expenses. It means lower investment, lower depreciation charges, and ultimately, it means lower prices to our customers, must necessarily, as it is just as uneconomical to charge your customers too much as it is to charge them too little. Neither pays. That is my experience of central station business.

Before I sit down I want to say something of the future. If you take the business of today, we in the Mississippi Valley do about 75 per cent of the possible business, outside of steam railroads and farms. But some day, when the ordinary voter realizes that his best interests will be served by seeing to it that the steam railroads of the United States are operated at such a rate of return as will give them first class credit, some day the steam railroads of the Mississippi Valley have got to be electrified. There are about 130,000 mi. of steam railroads, and it would require about 24,000,000,000 kw-hr. to operate them, or just about as much energy output as is the output of the central station companies in the Mississippi Valley today. Just see what that means in saving in natural resources to the country. It takes 83,000,000 t. of coal or thereabouts to operate the steam railroads of the Mississippi Valley today. If they were electrified there'd be a saving of about 75,000,000 t. of coal a year. That is a figure that staggers you.

Of course, as against that there is an enormous investment that has got to be made to change the motive power from steam to electricity, but if electricity is an economical thing to use over the mountain division of the Chicago, Milwaukee and St. Paul Railway, why should it not be an economical thing to use in the vast plains of the Mississippi Valley, where density of the use of the railroads is on the whole very much greater?

Now then, there is another phase of the business. Take the farms of the Mississippi Valley. If the farms of the Mississippi Valley were electrified, and today the amount of electrification is so small it is almost negligible, only about 6.5 per cent of them—if the farms of the Mississippi Valley were electrified; that is, if the farmer's housewife and the farmer could be relieved of some of the back-breaking chores that they have to do by just turning a switch, the amount of energy, if that could be accomplished over night, the amount of energy that would be used in this Mississippi Valley territory would be increased about 50 per cent from that source alone.

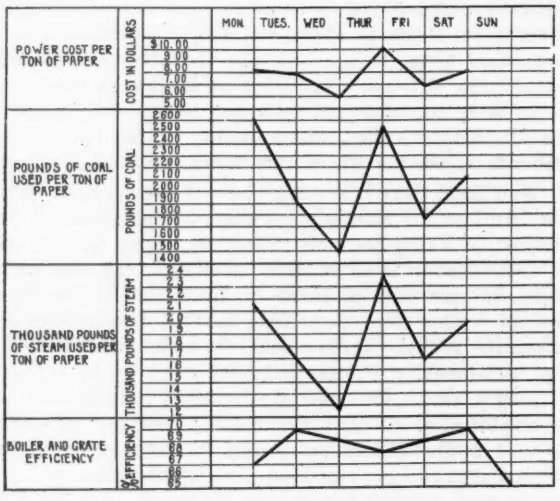
So even without figuring on the march of population westward, and it is now—the center of it is now just a few miles east of us—without figuring on the development of new consuming devices, without figuring on the vast increase in wealth that the increased use of machines must bring this country, because after all the only basis of wealth is labor, and you increase the capacity of labor and labor will become infinitely better paid, and the national wealth will be infinitely increased, but without considering any of these things, just looking at the business that is right at their door, all we have to do is extend this idea of expansion of the distribution system. There is enough diversity in the farm business that there'd be a relatively small plant investment necessary to take care of it; that is, primary generating plant investment to take care of it.

If we just go after that business—and I assume that in talking here I am talking mainly to men interested on one or the other side of the central station industry in the Mississippi Valley—if we just go after that which is right before us, there is 50 to 75 per cent possible increase in business, and if you add to that what comes from continued prosperity, what comes from increased purchasing power of our people, it looks to me as if we are no more than on the threshold of a great industry, notwithstanding the fact of the enormous progress made in the last 35 yr.

Engineers Should Control Power Production

INDUSTRIAL PLANTS ARE PRONE TO USE MORE POWER AND STEAM IN MANUFACTURING PROCESSES THAN ACTUALLY REQUIRED. BY LYNN L. ARMANTROUT

FAIR-MINDED acceptance of improved methods that have been established by expert research, with knowledge gained from practice and study, has enabled public utility plants to reach close to the maximum standard of efficiency in steam and electrical generation. This can be said for the public utility power plants interested in delivering economical electric power to the line, who obtain within their department every available heat unit from the coal and register it in kilowatt-hours on the board. The industrial plants, however, have only quite recently realized the importance of the power department in their manufacturing costs, and while they are making great strides in installing up-to-date plant equipment, most of them are far behind the operating accomplishments of the public utility plants.



GRAPHIC CHART OF POWER-PRODUCTION RECORD

Having economical plants in the industries is of national importance, since the largest coal consumers in this country are railroads, steel mills, paper, sugar, and chemical plants. Excepting the railroads, the largest coal consumers are industrial power plants whose total far exceeds the coal used by public utility generating stations.

In practically all large coal-using industries, the greatest cause for coal consumption is due to the steam and power requirements of their manufacturing processes. Their power plants are operated for the purpose of supplying live steam as well as electricity to the manufacturing departments. In such plants, a power cost and efficiency record system whose data is limited to the plant's operation as measured at the switchboard, represents only a small part of the actual power developed. Many of these industries find that power costs represent from one-third to one-half their conversion charges, and a few industries have even a higher power-production ratio.

Most of these large coal-using industries have reliable and well-informed chief engineers in charge of the generation of steam and electric power, but in only a few rare cases does this chief engineer have any right to go into the main factory to regulate or offer suggestions regarding the correct application of power for manufacturing purposes. Due to long established custom, the engineer is confined to the power plant and any effort he may make towards interesting himself in better methods of steam or power distribution and utilization, are likely to meet with strenuous resistance by the heads of these manufacturing departments.

We must assume for the purpose of this article, that the power plant is operated at the highest efficiency and that the cost of steam and electric generation is the lowest possible. Even so, in these large plants running their engines non-condensing or using bleeder type power units and having use for all exhaust steam in process work; the steam generating efficiency will not be the determining factor in the cost of power per unit of production.

To illustrate this point, a graphic chart made from records of an up-to-date paper mill is shown here. Data was chosen from day runs at wide intervals of time to get suitable variations. It will be noted that the "power cost per ton of paper," "pounds of coal used per ton of paper," and "steam consumed per ton of paper" vary directly with each other. The "boiler and grate efficiency" moves practically independent of the other items. The cost per "thousand pounds of steam evaporated" was practically constant. This shows a typical example of what little real influence the performance of the steam generating plant proper, has on final power-production costs. The power and live steam requirements and the production efficiency of the factory determine the power-production costs in such mills.

When we consider a plant operating non-condensing with all exhaust steam used for manufacturing, heating, etc., it is apparent that only a small portion of the power cost is represented in generating electric or motive power. In the case of a plant operating with 150 lb. gage steam pressure and using 5 lb. gage back pressure on the engines there are 1195 B.t.u. of heat entering the engines and 1156 B.t.u. entering the exhaust. Allowing a practical condensation loss, there is often 93 per cent of the heat in the steam entering the engine or turbine that comes out as exhaust ready for service in the manufacturing departments. Only 7 per cent of the heat in steam in this case is properly chargeable to motive power generation. In other words, out of every 100 t. of coal used by such a plant, only 7 t. are used for motive power, while 93 t. are used in heating, drying, and other process work. If the power cost per ton of paper is $10.00, $9.30 of this was used in the factory and its amount controlled in the factory departments, while only 70 per cent of it was controllable by the power plant. There are hundreds of plants all over the country making various products who are operating under similar conditions and while their costs may vary from the one given, the proportions mentioned are practically the same.

By referring to the graphic chart shown here as taken from a paper mill's power-production report, and using the first day's record of Monday as an example, we can illustrate the statements made in the preceding paragraphs. This mill made 130 t. of paper that day, was using $5.00 coal and its total power cost was 45 cents per thousand

pounds of steam developed. In order for the boiler plant to raise the power-production cost one dollar per t. of paper, the coal consumption per ton of paper would have to rise from 2616 lb. to 3016 lb., its boiler and grate efficiency would have to drop from 6 per cent down to 58 per cent, a loss of 9 per cent, which would be unusual. The steam cost would have to jump from 45 to 49.6 cents per thousand pounds of steam, which would indicate considerable trouble in the boiler room. Engineers never expect to operate their departments with such lax and apparent deficiencies and so would not expect their division of the mill to be responsible for an increased cost of one dollar per ton of product.

In the manufacturing divisions, however, a single man may often unknowingly be responsible for increasing the power-production costs one dollar or more. On the day in question, if a 1-in. live steam line or its equivalent is left open for 23 hr., the steam consumption per ton of paper would be 23.3 thousand pounds instead of 21 and would result in the power cost per ton of paper jumping from $9.40 to $10.40. This is only one example of what can and often does happen in the plant to influence the engineer's cost record.

Engineers of industrial plants must consider that the management is interested in investments and improvements for better efficiency only insofar as they affect the final power cost per unit of production. A power plant improvement that does not lower the power cost per ton of steel, paper or sugar, or whatever the product may be, will have poor chances for approval of the management in most plants.

With the production department playing such a predominating part in the power cost, the chief engineer of non-condensing plants certainly should have some authority to control the utilization of the steam he develops. Vast opportunities exist in every large plant, and proportionally in smaller plants, for promoting efficiency in the use of steam in these industries. Engineers who apply themselves to these problems in their respective plants are sure to increase their own knowledge to advantage, and bring recognition of the importance of their work from the management.

The chief engineer who realizes the opportunity for saving that exists in his factory and attempts to correct this condition, will find one of his hardest problems is in overcoming the established ideas of the management, who nearly always believes that the power plant man should stay in the engine or boiler room. In overcoming such a condition it is often a good plan quietly to get data on some one waste in the factory and use it as an example of what can be done. By citing a specific case and capitalizing on it, the decision can generally be made to favor the engineer's viewpoint.

To gain approval of the higher executives is only the first step, however. The main problem remains with the production superintendent and his foremen. The engineer must become a diplomat and use good judgment in winning the support of these men. Once they are convinced of the sincerity of the engineer and actually cooperate with him in saving power waste, the plant will begin to show a definite progress. No matter how hard an engineer may work or how capable he may be, there will be little real progress unless he has the whole-hearted support of the chiefs in the production departments.

In the larger industrial plants the chief engineer can present the subject to the manager and get his approval of the idea, and in a few cases he can arouse the enthusiasm of the foremen in the factory. The real working out of the matter must be turned over to a good engineer who will find all his time well taken up with this job alone. Such a man should be an experienced power-production engineer with training in this particular line. He should have the same official status as the production manager or superintendent, and the chief engineer. He must coordinate the interests of these two departments and promote good-will between these two branches of the plant.

In the medium and small plants the task must be handled by the chief of the power plant. Some small factories make the mistake of turning the power-production work over to a production official who knows little about power and as a result such plants always have endless confusion and no little ill feeling with small savings in the end. Every well informed engineer is capable of taking charge of applying steam efficiently in the factory and he should make it his business to do so. There are few chief engineers of small plants who cannot find time for such duties if they are really interested.

Establishing Records System

With the position and duties of the power-production engineer established in an organization, his first job will be to remedy the most obvious wastes in the plant. Then before trying to accomplish much more in the way of savings he must inaugurate a thorough system of power records if there is none existing. The writer recommends from experience, three sets of daily records besides the operating engineers hourly readings:

"The daily power distribution and efficiency report," showing the steam consumption of the various departments, with separate items showing that used by all large steam using units. The boiler efficiency report can conveniently be shown with this data also.

"The daily power cost record" showing the cost of steam and electrical generation, and the pro-rata charge to each department or unit figured from this cost, as indicated by steam consumption shown in the first record.

The third report is a summary of the other two, with special data calculated from the first two records. This is called the "Power Production Efficiency Report" and shows the power cost per unit of production, coal used per unit of production, and steam used per unit of production. The kind of work done in the factory at the time the record was made should be known in factories, like sugar, paper, and chemical plants, which make a fairly uniform product that can be readily noted on the power record. Their power requirements may vary with the grade of material made, and it is well for the engineer to note this in order to judge whether or not a certain power-production variation is justified.

Engineers often see that their power plant is operating with obsolete and inefficient units and naturally they want to correct this condition. Before they proceed with the subject it should be noted that an engine room using only 7 per cent of the energy generated from the coal must be able to show an unusually large saving to justify any great expenditure for new equipment. There are many cases, of course, where a defective turbine or engine will use too much steam, and allow too much steam to pass into the exhaust system without having its pressure reduced.

This operation may reach a point where this volume of steam cannot be used in process work and the pressure will build up in the system so exhaust steam must be let out to the atmosphere. Improvements in such a case would certainly pay and would surely show a reduced power-production cost.

In order to secure executive approval for such a change he must have records and a collection of facts to support his claim. It is generally conceded that anything which tends to make better and healthier conditions in the plant, pays big dividends in money to the stockholders of a mill. The plant engineer, however, cannot rely on humanitarian impulses to secure approval of his recommendations for better power equipment. Any request of his that necessitates the expenditure of a considerable sum of money, must be accompanied with a detailed array of data for justifying the investment in terms of dollars and cents.

These three reports will prove of everyday value for locating any faulty operating characteristics of the factory. Their most valuable use, however, is as a basis for preparing comprehensive estimates for proposed improvements, and as a means of checking savings made by such improvements. Savings made can then be shown to advantage, and credit for it given the proper persons.

Increasing Power Economy

Having established a set of reliable records the engineer can proceed with the task of regulating the steam consumption in the production divisions. The visible wastes like leaky packing glands, joints, or traps blowing to atmosphere having been tended to, the large invisible wastes and their causes remain to be disclosed and remedied.

Factories usually have a live steam header or pipe line running the length of the machine rooms, with branches from it into all vital units and heating coils. Wherever exhaust steam is used there will be found a live steam connection. This is the source of the most common wasteful practice. Whenever the coil, water, or heater, gets cool the live steam is turned on. It is seldom as readily turned off when the unit is warm again. In fact many times live steam will be left on until the back pressure throughout the entire system begins to rise noticeably, and the operating engineer notices it.

Investigation usually shows that in such cases the real cause of the trouble was in a faulty trap or return system which stopped the circulation of steam in the unit that went cold. The average factory machine operator cannot be expected to know that his heat depends more on proper circulation than on pressure. A low exhaust pressure with good circulation is better than high pressure and no circulation. Big savings can be made by keeping traps and vacuum return systems working properly so the operators will not need to turn on any live steam.

Hot water heaters and vats are big users of steam. In one case it was found that the men using water would not turn in cold water to fill the container until it was so low that the exhaust steam could not heat the refilled tank quickly. This caused operators to turn in live steam to hurry up the job. An automatic water level regulator was put on this unit and thereafter the water entered at a fairly uniform rate and no live steam was needed for heating it. Production was benefited and steam saved.

When the chief engineer or power-production man gets thoroughly acquainted with the steam consuming units of the manufacturing departments, by checking the daily power-production records he can quickly locate any unusual power waste and can take immediate steps to eliminate it. This will eventually result in his standardizing the power-production requirements and costs for his individual mill. The most economical power rate for each unit will be established, as in public service stations, which should result in a uniformly high standard of operation; the attainment of which will make the same efficiency in the utilization and application of industrial power, that has been accomplished in power generation.

By establishing themselves in both power and production departments of a mill the standing of the engineers in industrial plants will be materially advanced in their own organizations. Factory managers of such industries most certainly will not abandon efficient private power plants when they are such a vital contributing element in production. They will realize full well that the power department is not an over-head expense or unnecessary evil, but that it and the chief engineer are as productive as any other department of their factory.

Refractories for Boiler Furnace Walls

By H. C. Thayer

IT IS well known that fire brick, like most other materials, expands and contracts under the influence of temperature changes and in addition, high set boiler furnaces supported on structural steel work are subjected to

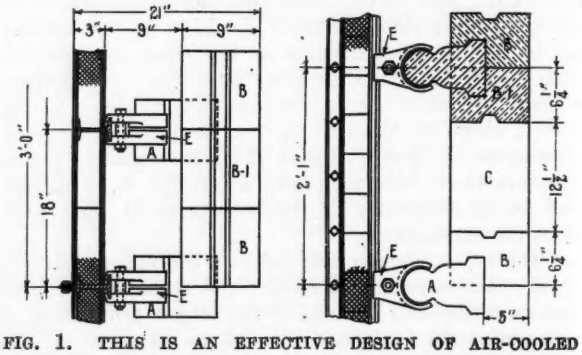


FIG. 1. THIS IS AN EFFECTIVE DESIGN OF AIR-COOLED FURNACE WALL, USING SPECIAL REFRACTORY BLOCKS SUPPORTED IN SECTIONS INDEPENDENT OF EACH OTHER. TO THE LEFT IS A PLAN VIEW AND TO THE RIGHT, A SIDE ELEVATION

vibrations which prohibit the use of rigid masonry. As a result of many years experience in refractory problems, the writer has developed several designs of furnace walls which overcome these difficulties.

Figure 1 consists of a 9-in. fire clay shape wall, a 9-in. circulating air space and 3 in. of insulation consisting of ⅛-in. steel plate, ⅛-in. asbestos mill board, 2½ in. of insulation brick laid on side, ⅛-in. asbestos mill board and a ⅛-in. steel plate casing. Steel I beams (4 in.) are placed at intervals of 18 in. and framed into horizontal supporting members not shown. Onto these beams the double cast-iron clip "E" is fastened and it will be noted its design is such that air passing up between the castings and the flange of the steel beam, eliminates any possibility

of heat loss by conduction. The circular jaw of this casting grasps the block "A" which in turn is rigidly held by blocks "B" and "B-1."

Ordinary 9-in. brick could be used instead of the block "C" if desired but use of this block eliminates 36 linear in. of exposed joints. Horizontal or lateral expansion or contraction is cared for by the neck of the block "A" sliding in the circular jaw of the casting "E", while the circular neck of the block "A" rolling in the casting absorbs vibration. Provision is made for upward expansion or downward shrinkage by the casting "E" riding on the flange of the steel I beam.

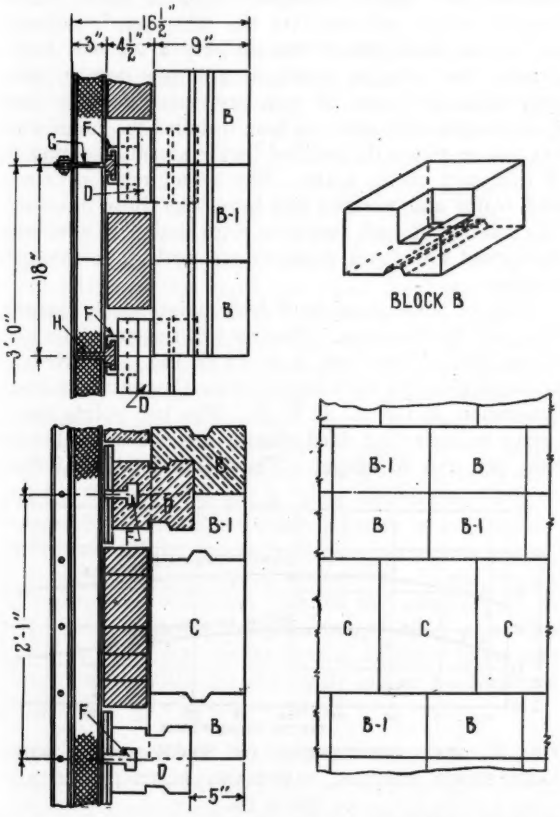


FIG. 2. THIS IS ANOTHER DESIGN OF AIR-COOLED FURNACE WALL. TO THE LEFT, THE UPPER DRAWING IS IN PLAN AND THE LOWER IS A SIDE ELEVATION

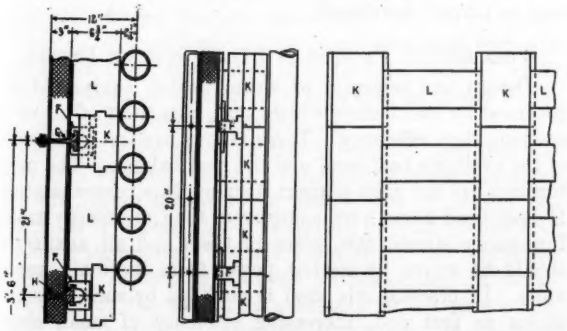


FIG. 3. WATER-COOLED TUBES ACT AS A SCREEN TO THIS WALL WHICH IS ALSO AIR-COOLED SIMILAR TO THE OTHERS

In Fig. 2 there is a 9-in. fire clay shape wall, a separate 4½-in. backing wall and a 3-in. insulation wall similar to the one previously described, excepting that the inner steel plate and asbestos mill board is replaced by a ¼-in. asbestos mill board. Cast-iron bonding beams are used in place of steel I beams. The cast-iron clip "F" is inserted in block "D", then the block is lifted up and the casting slipped over the lug on the bonding beams "G" and "H". Blocks "B" and "B-1" hold block "D" rigid, thus providing for expansion, contraction and shrinkage.

This type of wall can be used as shown, or protected by water screens, because facilities are provided (by omitting the lugs on block "C" at each fourth course) for making repairs from the outside of the setting, similar to Fig. 1.

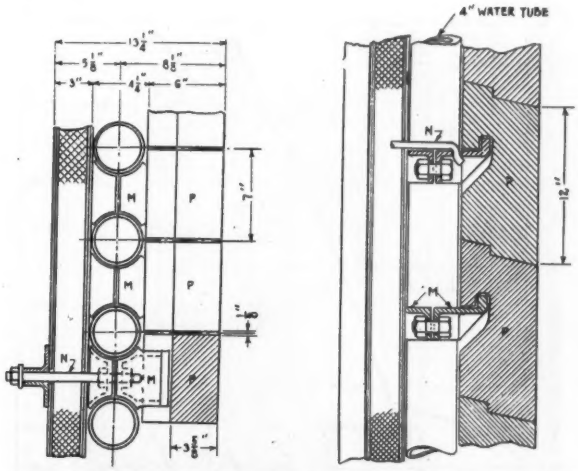


FIG. 4. SOMETIMES, AS SHOWN HERE, AIR-COOLED WALLS ARE DESIGNED WITH WATER TUBES BEHIND THE WALL TO ASSIST IN CARRYING OFF HEAT

In Fig. 3 is illustrated a type of thin wall designed for use with water screens which absorb enough surface heat to keep the fire clay blocks below the fusing temperature of the ash in the fuel. This wall consists of a 6¾-in. fire clay shape wall and a 3-in. insulation wall, similar to Fig. 2. Cast-iron bonding beams, previously described, are used. The cast-iron clip "F" is slipped onto the lugs on the bonding beams and then followed by block "K" which is provided with tongues on the side holding the block "L" in alinement. Provision is made for expansion, contraction and shrinkage, as in previous designs.

Figure 4 shows a wall particularly designed for the burning of bagasse, hog fuel, or lumber shavings. These fuels are far more destructive to refractories than coal, oil or gas and therefore must be handled differently. This wall consists of water tubes to which is clamped the casting "M" and to which, in turn, are suspended the refractory blocks. The tie bolt "N" is inserted into the hole in the casting "M", passes through the insulation and is fastened as shown. Each individual block being supported separately, the removal of the load permits higher temperatures before fluxing will occur. By properly regulating the volume of water passing through the tubes, the desired ignition temperature can be maintained, without reaching temperatures destructive to the refractory.

ONE OF THE most important factors in the success of firing with oil is the proper draining of the fuel oil storage tanks. The presence of water in the oil that goes to the burners causes no end of trouble.

Trend of Steam Power Plant Development

DECREASE IN COAL CONSUMPTION, INCREASE IN FIXED CHARGES, AND INCREASE IN SIZE ARE OUTSTANDING FEATURES. BY A. G. CHRISTIE*

DURING THE past decade, remarkable developments have been made in improving the economy of steam power plants, particularly of the large central stations. This is made evident by noting the performance of typical American plants of 60,000 kw. and higher. Stations put in service in 1915 required about 20,000 B. t. u. per kw.-hr. of net station output while some of those initially operated in 1925 required only 15,000 B. t. u. per kw-hr.

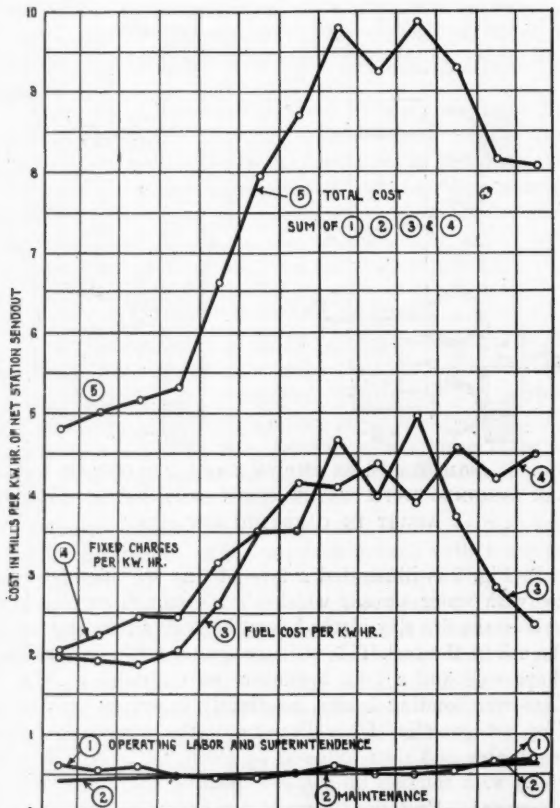


FIG. 1. TREND OF OPERATING COSTS AND FIXED CHARGES FOR TYPICAL STATIONS OF 60,000 KW. AND HIGHER

This represents a decrease of 25 per cent in coal consumption in 10 years. While further gains are still possible, other factors which have increased in relative importance, particularly increasing fixed charges, may delay any great decrease in coal consumption.

LOAD FACTOR INFLUENCES STATION DESIGN

Load factor has a great influence on steam station design. The influence on costs of daily, monthly or annual load factors may be stated briefly as follows: (a) Daily load factor and the form of load curve affect fuel costs; (b) Monthly load factor affects labor and fuel costs; (c) Annual load factor affects fixed charges.

High annual load factors will warrant considerable refinement and higher investment costs to secure the increased station economy. On the other hand, extremely low annual load factors warrant only a low cost station because fixed charges constitute a larger item in power costs while fuel costs in such cases are relatively lower. Much special equipment has been installed the use of which was not economically justified by the actual operating life of that part of the plant. The actual relation between load factor and working life have been fully discussed.† The relation of load factor to plant design is now better understood and fewer mistakes are made than in earlier designs.

Cost of power consists of fuel, maintenance, operating labor and fixed charges. The trend of these separate items of cost and of total cost is shown in Fig. 1, which is reproduced from the 1925 Report of the Committee on Power Generation of the A. I. E. E. The last points on the curves indicate that fixed charges are almost double fuel costs per unit of output. These considerations indicate

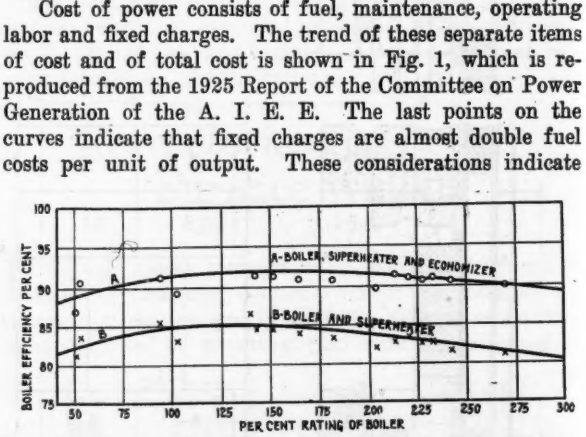


FIG. 2. TEST EFFICIENCIES OF 30,600-SQ. FT. BOILER, LAKE SHORE STATION, CLEVELAND ELECTRIC ILLUMINATING CO.

that the foremost problem confronting designers today is the reduction of initial investment in the plant so that the trend of the curves for fixed charges and for total costs may be turned downward.

THEORETICAL FACTORS IN STEAM STATION DESIGN

Design and selection of steam station equipment are governed by two factors which have been most effective in securing high efficiency. These factors are the ultilization of the available heat head and the heat balance. The main turbines are the most efficient elements in a central station. If heat head alone were considered, then all energy transformations should take place in them and all auxiliaries should be driven by electric power from the main generators. In practice this ideal is modified by such considerations as first cost, increasing efficiency of small steam turbines, reliability against shut-down, and space requirements. Heat head has been fully discussed in another paper.‡

Heat balance is more comprehensive than heat head utilization. It implies a study of the plant design as a whole so that the greatest economical amount of heat energy in the coal may be delivered as electric power to the feeders leaving the station. Due regard must be given to

*Professor of Mechanical Engineering, The Johns Hopkins University, Baltimore, Md. Abstract of a paper presented Jan. 28, 1926 at the annual meeting of the Engineering Institute of Canada at Toronto, Ontario.

†"Obsolescence a Factor in Power Plant Design," Peter Junkersfeld, Power, June 12, 1923.

‡"The Utilization of Heat Head," A. G. Christie, Power, Dec. 2, 1924.

costs of obtaining such performance and all gains must be balanced against the increased cost of securing such improvements. Heat balance studies have resulted in the use of higher steam pressures and temperatures, reheating of steam, powdered coal, air preheaters, bleeder heaters for feed water evaporators, and the various systems of electric drives for auxiliaries.

Steam Pressures and Temperatures

By 1920, steam pressures had risen to 300 lb. and steam temperatures to 700 deg. F. Rapid advances have been made in the last five years so that there are several stations in the United States with pressures between 550 and 600 lb. A 1200-lb. boiler is going into operation in one station, while in England an experimental boiler with 3200-lb. steam pressure has been in operation. Steam temperatures, however, have increased only to 750 deg. F. For several years the writer has urged the desirability of increased steam temperature and demonstrated the economic possibilities of higher temperatures in a recent paper.* Increased steam temperature involves increased expense only in superheater, the main steam header and valves, and in the first stages of the turbine. Higher boiler pressure requires increased expense for all equipment from the boiler feed pump practically to the turbine exhaust. On the other hand, steam consumption will be decreased by either higher steam pressure or higher temperature and smaller pumps, boilers, superheaters, piping, and condenser equipment will be required. At the present time power plant designers look to the metallurgists to develop steels suited for higher temperatures than 750 deg. F. In the meantime the general tendency is towards higher pressures although eventually higher temperatures than 750 deg. F. will also be used.

Structural Features of Design

Building and foundations may account for one-fifth to one-third or more of the total cost of the plant and they are more controllable on a given site with given requirements than steam or electrical equipment. Many variables, such as amount and topography of available ground, soil and flood conditions, circulating water supply and levels, rail service, etc., are encountered with every power house site. It is seldom, if ever, possible to build from the same design two power plants in different locations. Skillful arrangement of equipment is necessary to reduce building costs in any large measure.

Volume is the more generally accepted unit for the comparison of plant designs. Considering boiler plants as now built, there appear to be possibilities of further developments in design and of reduction in total volume and cost of the structures. Turbine room height and width are fixed by the requirements of the condenser and its auxiliaries, and by the clearances necessary to lift covers and remove rotors from turbines and generators. It has been suggested that vertical condensers would permit reductions in roof height and lessen turbine room volume. Much of the electrical equipment formerly housed inside the building is now placed outside and this has decreased building expense. The trend now is towards simple plain low-cost designs and in some cases reinforced concrete has been used in place of structural steel and brick. Much money may be needlessly spent on the station structure and careful study of this feature can often effect large savings in total plant cost.

Modern Boiler Plants

Modern boiler plants have four outstanding characteristics; namely, increased boiler size, high ratings in operation, new furnace designs and automatic control.

Increased boiler ratings are now possible through improved furnace designs which produce higher efficiency over a wide range of load. Combined boiler, superheater, and economizer efficiencies, as found by tests on a 30,600 sq. ft. boiler at Lake Shore Station, are shown in Fig. 2. This curve is remarkably flat over a wide range of load.

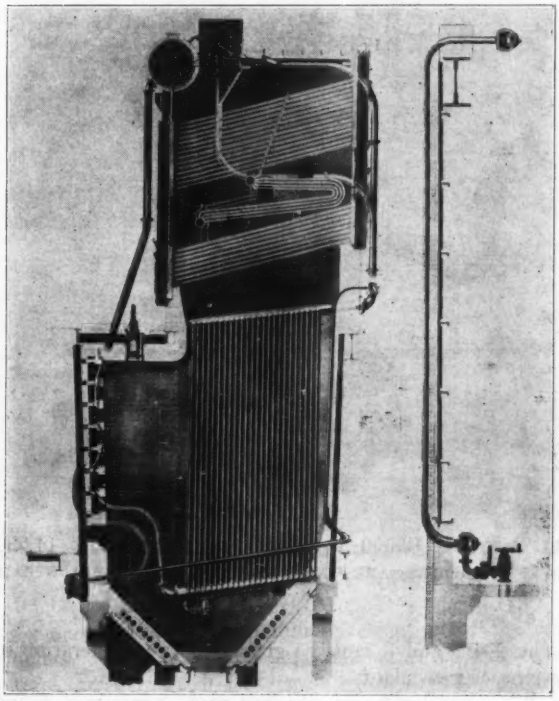


FIG. 3. SECTION THROUGH B. & W. BOILER NO. 11 AND FURNACE AT CAHOKIA. HEATING SURFACE IN BOILER, 18,010 SQ. FT., IN WATER SCREEN AND FIN-TUBE SIDE WALLS 1188 SQ. FT., FURNACE VOLUME ABOVE WATER SCREEN, 13,500 CU. FT.

Few boilers are now operated continuously at ratings above 300 per cent. Air preheaters tend to flatten the boiler efficiency curve so that operation at peak-load at much higher boiler ratings than 300 per cent does not require much sacrifice in fuel economy.

The cost of furnace and setting, air-preheater, and forced and induced draft fans, will be increased when high ratings must be carried, but these increased auxiliary costs are small compared with the costs of complete additional boiler plant. High boiler ratings tend, therefore, to lower the first cost and are often justified on this basis for the given load conditions.

These higher ratings are possible only with improved furnace designs. General statements on the relative cost of pulverized coal systems and stokers are dangerous to make because other factors must be considered besides the mere item of first cost of this equipment alone. When all factors are considered the differences in cost become

*"Higher Pressures or Higher Temperatures," A. G. Christie and D. C. Turnbull, Jr. Report of Prime Movers Committee, N. E. L. A., on Higher Steam Pressures and Temperatures, July, 1925.

small and may favor either system depending on local conditions. Unit pulverizers are under the same conditions, less costly than central pulverized coal systems. Powdered coal equipment requires more auxiliary power than stokers. On the other hand, it gives a higher efficiency over a wide range of boiler ratings and is more independent of the grade of coal than the best stokers. Powdered coal more nearly approaches test efficiency in daily operation and has lower stand-by losses and lower maintenance costs than stokers. These factors have warranted its installation in many stations. The use of pulverized coal

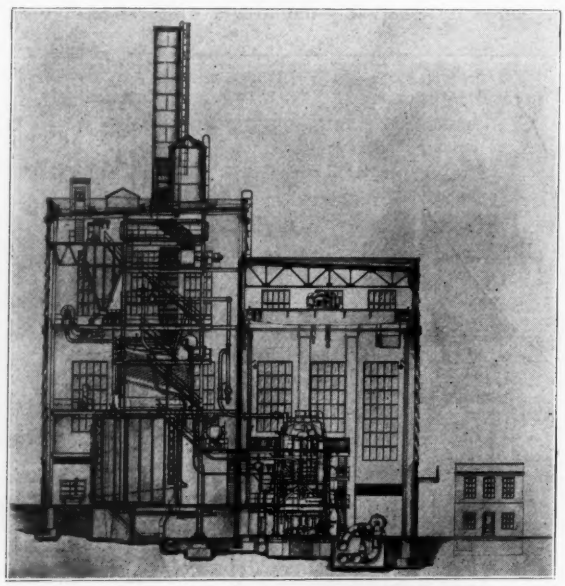


FIG. 4. TWO 12,500 KW. TURBINES AND THREE 14,050 SQ. FT. BOILERS ARE INSTALLED AT HOLTWOOD STEAM STATION

is increasing and it must be given serious consideration in designs of new plants.

When powdered coal was first used, it was soon found that solid walls of the best grade fire-brick would not always stand the increased furnace temperatures. Air-cooled brick side walls were tried with considerable success, but studies of furnaces* indicated that the benefits of the radiant heat developed in the flame were not fully realized when brick walls were used. It was suggested that the furnace be wholly enclosed by water-cooled walls to absorb the greatest possible amount of radiant heat. Figure 3 shows such a furnace setting in the Cahokia Station of the Union Electric Light and Power Co.

With water-cooled furnaces, the entering air should be preheated and furnished in slight excess (10 to 15 per cent) over theoretical requirements. This combination of water-cooled furnace walls and air preheater seems in practice to offer the most economical combination. Future boilers may be built *around* the furnaces rather than entirely *above* them.

Some refractory lining seems to be required in certain furnaces such as those burning pulverized coke or anthracite. This may be of the standard air-cooled brick-and-tile design now in use in some pulverized coal plants, or may consist of a refractory lining on water-cooled walls.

*"The Influence of Radiant Heat on Furnace Design," A. G. Christie, Power, May 29, 1923, also, "Boiler Furnaces for Pulverized Coal," A. G. Christie, Mechanical Engineering, August, 1925.

Figure 4 is a cross section of the new Holtwood Station of the Pennsylvania Water and Power Co. where furnaces with air-cooled side walls were installed to burn either a good grade of powdered bituminous or powdered anthracite coal. This station, one of the newest of the steam stand-by stations to a water-power development, has turbines designed to float on the system at peak load and to carry loads in excess of the hydro plant capacity. They may at times be motored during fluctuations in load.

It is not always economical entirely to supersede an old station which may be favorably located. Such stations generally have stokers with small furnaces, hence operate at relatively low boiler efficiencies. Increased efficiency has been secured by rebuilding such furnaces for powdered coal. Figure 5 shows such a rebuilt furnace under a 5580-sq. ft. boiler at the Ashley St. Station of the Union Electric Light and Power Co., St. Louis, Mo.

Powdered fuel firing lends itself admirably to full automatic control for which several systems have been developed. These control systems have maintained the aver-

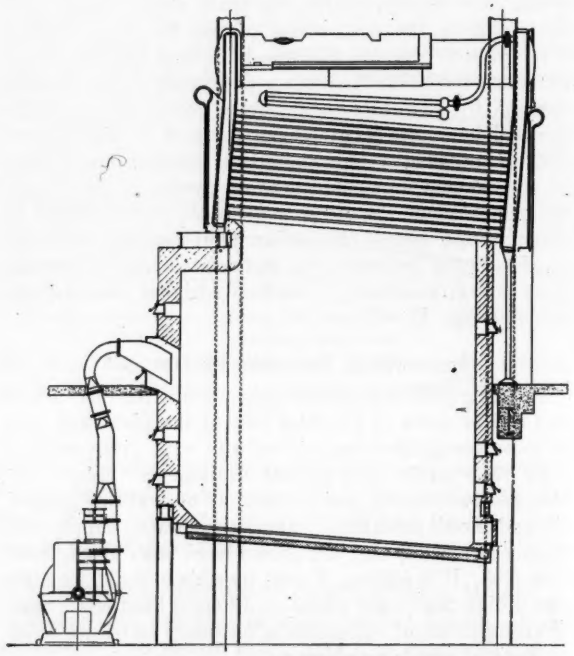


FIG. 5. FURNACE OF BOILERS NO. 19 AT ASHLEY ST. STATION WAS REBUILT FOR PULVERIZED COAL, USING UNIT PULVERIZER AND REFRACTORY FACED WATER COOLED SIDE AND BOTTOM WALLS IN 5230-CU. FT. FURNACE

age daily boiler efficiency on varying loads within a few per cent of test efficiency.

Feed Water Treatment and Heating

Careful study is now given to the treatment and heating of boiler feed water. Surface condensers are generally installed with all large steam turbines and the condensate, being pure distilled water, can be returned to the boiler as feed water. Troubles with boiler corrosion and oxidation of blading in steam turbines, have been traced to the presence of free oxygen in solution in the feed water. Deaeration may be accomplished in the condenser itself or in separate deaerator-heaters specially provided for this purpose. Make-up water should be supplied from evapo-

rators after such preliminary chemical treatment as the raw water may require.

The most efficient method of heating feed water is by means of steam, bled at several stages from the main turbine. Heaters are usually of the closed type, generally horizontal, and may be located either under the turbine or elsewhere as desired. Vertical closed heaters of the hairpin type, first used at the Westport Station of the Consolidated Gas, Electric Light and Power Co. of Baltimore, Fig. 6, are of a later design. While it is desirable to heat the feed entirely with bled steam, every other source of waste heat in the plant should be utilized in heating feed water.

Centrifugal pumps for boiler feed are generally provided with one steam driven pump for starting up and for emergency service while the others are motor-driven. These pumps may be provided with automatic control. The feed to the individual boilers is usually governed by automatically controlled feed water regulators.

Size of Steam Turbines Increases

Capacity of individual turbines has increased rapidly during the last few years. Units of 30,000 kw. are common and turbines with outputs of up to 60,000 kw. are in daily operation. A 75,000-kw. turbine has been ordered for Crawford Ave. Station, Chicago, and an 80,000-kw. unit for Hudson Ave. Station, Brooklyn.

Steam turbines have been developed to a high degree of efficiency and reliability. Refinements in design permit some further gains, which, however, will come slowly. The largest turbines show only slight improvement in steam economy over the medium sized units. If the initial superheat can be materially increased, or if the steam can be resuperheated when it has expanded almost to the saturated condition, the deleterious effect of moisture in the turbine will be removed, the efficiency increased and the steam consumption lowered. To reheat between stages the steam must be carried back to a reheating superheater in the boiler. This additional complication, together with resultant boiler and turbine control problems, have made engineers reluctant to adopt reheating except where unusual base load conditions prevail and where high pressures are used.

Closed air-cooling circuits are standard on turbo-generators with closed-type fin-tube coolers to remove the heat losses. This system lessens the danger of fire in turbo-generators, lessen the noise in turbine rooms and provides a neat, compact design. Electrical engineers are now considering the use of hydrogen or other gases instead of air for cooling turbo-generators. The trend is still towards increased size in steam turbines and single units of 100,000 kw. may be expected within a reasonable time.

Condenser Design Being Improved

Surface condensers are used where possible with large turbines as they produce a higher vacuum, require less auxiliary power than jet condensers, and also provide pure condensate for boiler feed. These may be single- or multi-pass, depending on whether there is an abundant or limited supply of cooling water. Developments are largely confined to improvements in tube space which will make all the cooling surface equally accessible to the exhaust steam and will cause this steam to sweep in straight lines towards the air cooler section.

In some cases the character of the cooling water, due to foulness, acidity or other causes, prohibits the use of surface condensers. Jet condensers must then be used and special provisions must be made to treat all the raw feed water.

Steam jet air pumps are favored on many installations due to their cheapness, their simplicity, the high vacuum attainable and the small space requirements. Reciprocating dry vacuum pumps may in some cases make a lower steam demand on the boilers and may produce higher vacuum than with steam jets. These advantages are offset somewhat by high first cost, large space requirements, and generally higher maintenance.

Auxiliary Drives Must Be Reliable

The prime requisite of an auxiliary drive is reliability; high efficiency is a secondary consideration.

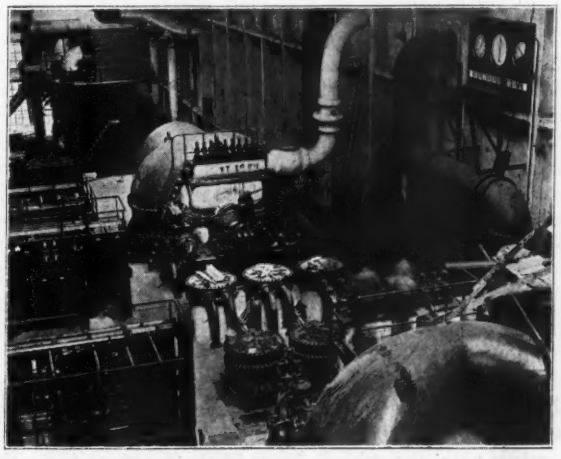


FIG. 6. WESTPORT STATION IS EQUIPPED WITH HAIRPIN TYPE EXTRACTION FEED WATER HEATERS, SHOWN IN CENTER BETWEEN TURBINES

Some auxiliaries are absolutely essential for the continuous operation of the station, such as boiler-feed pumps, powdered coal feeders, or stoker drives, condenser auxiliaries, unit pulverizers when used, draft equipment, and exciters; others may be subject to interruption with no serious effect on operation, such as coal handling and pulverizing equipment for storage systems, service pumps, air compressors, etc. The first class if electrically driven, must secure power from a source not subject to line interruptions. House turbines of efficient design often operating condensing, are used in some plants. In others, auxiliaries are supplied with power from the main unit through an auxiliary bus, with an automatic throw-over onto a spinning house turbine in case of trouble. Another plan is to connect an auxiliary transformer to the main generator inside the switch gear and reactance coils, and to furnish auxiliaries with power from this transformer.

Still another plan is to provide an auxiliary generator driven by the main turbine and placed beyond the main generator. A low cost stand-by non-condensing house turbine may be provided for starting up and emergency service. There is a wide difference in practice on this matter of auxiliary drive for normal and emergency operation.

Some designers prefer to install duplex sets with both turbine and motor drive for all essential auxiliaries. Improvements in the efficiency of small turbines tend to encourage such installations. The design of turbines of sizes used for house service is being further developed so

that their efficiency will be only a little below that of the main units.

Steam Stations for Industrial Plants

The preceding discussion refers specifically to large central stations. Many industrial plants require a steam station to furnish steam for heating or process work or for power. The use factor of such equipment may be quite high in which case refinements in design would be warranted that could not be justified with a low use factor.

While the same general tendencies prevail in industrial plant design as in central stations, the former lag behind, due partly to the fact that the industrial steam plant is a secondary part of the whole works and partly because less efficient operating management and personnel are available in the small plant than in the large electric works.

Increasing boiler pressures, larger boilers of the water-tube type, pulverized coal or more modern stoker equipment, and large condensing or non-condensing steam turbines, now characterize the equipment of the larger industrial plants. There appears to be a tendency in European industrial plants where process steam is required to use even higher steam pressures than in central stations practice. A careful analysis of this use of higher steam pressure has been presented in a recent paper.*

Small plants are usually built with little or no thought given to fuel economy. Owners would save money by engaging competent engineering advice before building such small plants.

In the new boiler plant of a Canadian paper company, the Lopulco pulverized coal firing system will be installed, with a central pulverizing plant using steam dryers and located near the wharf some 1200 ft. away from the boilers. This plant is designed to burn any available coal, including Nova Scotia coals with low-fusing ash. An addition to the boiler room of another Canadian industrial plant consists of a 700-hp. boiler to be initially operated at 130 lb. gage pressure but built for 350 lb. gage. A superheater to provide 100 deg. F. steam temperature will be added later. A Fuller-Bonnot unit pulverizer will furnish powdered coal to the solid wall combustion chamber. Secondary air will be admitted through a hollow bridge wall. No water screens will be used on this plant. The unit will operate at 250 per cent rating with peaks up to 300 per cent. An old economizer now in place will be used to heat the feed water.

The recent development of high pressure accumulators has directed the attention of engineers to the possibilities of this equipment. In large central stations, the principle of conservation of heat head together with the flat boiler efficiency curve over wide ranges of load, do not leave much opportunity for accumulators to effect savings. Another situation prevails in the process work of industrial plants, particularly where widely fluctuating steam demands are common. Heat head is then of less importance than heat capacity.

Wide interest is apparent in low temperature carbonization processes as a means of furnishing a smokeless substitute for anthracite coal and of providing valuable by-products. These processes consist essentially of heating bituminous coal or lignite at temperatures not in excess of 1200 deg F. and thereby driving off the rich gas and the light oils which, not being exposed to high temperatures, contain portions suitable for use in automotive engines. The coke residue can be used either for domestic purposes or for pulverized fuel.

Although many processes have been invented and several are in advanced stages of development, none are in full commercial operation. It is probable that a few of these will be worked out so that they may be incorporated in future plant design.

Present trends of steam plant development are briefly presented in the preceding paragraphs. There may be differences of opinion among engineers in regard to the interpretation of these trends. Furthermore, the art of steam power plant design is still undergoing rapid change and the trend of development may be quickly modified by new thoughts on power production. This whole discussion indicates that one can look hopefully for better fuel economy and lower power costs from new steam power stations.

*"The Value of Higher Steam Pressures in the Industrial Plant," W. F. Ryan, presented at December, 1925, Meeting of A.S.M.E.

Spontaneous Combustion of Coals

In the course of a study of the spontaneous combustion of coal, being conducted by the Bureau of Mines, Department of Commerce, at its Pittsburgh Station, an adiabatic calorimeter has been constructed for the purpose of studying the heating tendencies of various coal samples under conditions permitting the elimination of all variables affecting spontaneous combustion save that of oxidation itself. The normal heating rate due to oxidation alone is then obtained. After once establishing this characteristic for a given coal, other variables are introduced and their effects studied.

Characteristic normal heating rate curves have been established for coals of different ranks from lignite to anthracite. Except for the semi-bituminous coals and anthracite from a temperature of 40 deg. C., heating rates are proportional to the temperature; with semi-bituminous and anthracite, the heating rates are practically constant. Variation in size of the coal under test does not affect the shape of characteristic heating curves. Heating, however, is very much intensified by reduction in size. Thoroughly dried coals heat less rapidly than those containing a little moisture. A moist coal will heat or cool depending on its degree of saturation relative to the air with which it comes in contact. With dry air and moist coal the latent heat of vaporization of the moisture taken to saturate the air may well be sufficient to over-balance the heat developed by oxidation.

Columbia Power Station Serves Southwestern Ohio

In the list of equipment accompanying the above article, which appeared in our Feb. 1, 1926, issue, we unintentionally omitted the item that all boiler breechings at Columbia were furnished by Connery & Co., Inc.

In addition to the pumps noted on the above list, three vertical feed water make-up pumps were supplied by Yeomans Bros. Co. and installed on the concrete clear water tank. Each of these is designed for 100 g.p.m. against 145-ft. head and is driven by a vertical, 15-hp., 1800-r.p.m. General Electric squirrel cage motor. Yeomans Bros. Co. also supplied four vertical motor-driven bilge pumps, one 50-g.p.m. pump for the oil purifier house, one 250-g.p.m. pump for the ash pump house, one 50-g.p.m. pump for the powdered fuel house and one 50-g.p.m. pump for the track hopper pit. These are driven by G. E. vertical motors.

Industrial Use of the Diesel Engine*

CONSIDERATION OF DIESEL INSTALLATIONS INVOLVES EFFICIENCY, COSTS OF FUEL AND LUBRICATION, MAINTENANCE AND FIXED CHARGES. BY MAX ROTTER†

IN THE FAMILY of prime movers, the Diesel engine is the youngest, nearly being a 20th century child. The first Diesel to be put into commercial service in the world, was a twin-cylinder, 60-hp. engine. This was installed in a brewery, in the winter of 1898, only 27 yr. ago, and was discarded about 10 yr. ago to give place to Diesel engines of larger capacity.

Industrial plants were quicker than central stations to take advantage of the high efficiency of the Diesel engine, and up to the end of 1914 they led in the total installed horsepower by about two to one. It might be assumed that this was due to the relatively small capacities in which Diesel engines were then being built; but this can scarcely have been the reason, as many central stations, especially for public service in small municipalities, even today require capacities below those available in Diesel engines 20 yr. ago. The true reason is probably the necessity of combating keener competition in industries than in central stations.

Today, Diesel engines are the sole or the preferred source of power in many industrial plants, many of which require continuous operation against heavy loads or, like irrigating plants, uninterrupted operation over periods of several months. In these industries the Diesel engine has fully proved its entire reliability, so that this factor does not enter into its consideration as a prime mover.

SIX SOURCES OF POWER AVAILABLE

When selecting the means for supplying the power required for an industrial plant, the field of choice extends over:

(1) Purchased Power,
(2) Hydraulic Turbines,
(3) Steam Turbines or Engines,
(4) Gas Engines,
(5) Gasoline and Light Oil Engines,
(6) Diesel or Heavy Oil Engines.

Fifteen years ago the capacity of the largest Diesel engine unit obtainable in this country was only 450 hp.; today it has reached 5000 hp. or 3500 kw. The unit capacity, therefore, no longer excludes the Diesel engine from consideration for even the largest industrial power plants.

The whole question as between purchased power, steam and the Diesel, usually resolves itself into one of comparative power cost alone. Of these means, hydraulic turbines and gas engines come into consideration only under special and localized conditions and gasoline and light oil engines only for small plants. The choice, therefore, usually lies between purchased power, steam and the Diesel. As between these, it is not wise to conclude, from superficial promises, that one or the other is best suited to the case under consideration.

So many factors affect ultimate economical results that a thorough analysis of each individual case, and of all of the conditions which bear upon it, is essential to arrive at a commercially sound decision. The most efficient prime mover is not always the most economical; nor the lowest priced always the cheapest. It is usually possible to determine most of these factors in advance and then it is not difficult to apply these to each means of power supply.

CONSIDERATIONS OF INSTALLATION COSTS

Cost of installing a prime mover is determined by three main conditions, namely, the requirements, the locality and the cost of the plant.

Power requirements comprise the amount and period of the load, as shown both by a daily load curve and the total annual horsepower-hours or kilowatt-hours. The fuel consumption, labor and other operating expenses can be closely calculated from these requirements and will vary according to locality for the same load conditions, or with load conditions in the same locality. The results may be modified by special requirements, such as hot water or steam for heating or industrial processes.

Possessing the unique characteristic that efficiency is affected but little by the size of the unit, a multiplication of Diesel units to obtain a high load factor is, therefore, less objectionable than in the case of a steam plant—an advantage which is enhanced by the readiness of the Diesel engine to be put on load at any moment without advance preparations. Besides, the Diesel maintains almost its full efficiency over a considerable range of load. At half-load its unit fuel consumption increases only about 15 per cent, while that of a steam engine plant is increased by about twice this amount.

It is, therefore, less important to consider efficiency when determining the number and size of the Diesel engines for a power plant than of the units for a steam plant, thus making it possible to accommodate the equipment of the Diesel plant to the most economical and available space without substantial sacrifices in efficiency or operating costs.

Of the operating expenses, the cost of the fuel is the most important. There was a time when coal and fuel oil respectively were so cheap in certain localities that the lowest priced power equipment was the most economical, even though the least efficient. That day has passed and with it there are steadily becoming fewer and farther apart those localities where fuel oil is so cheap that it is more economical to burn 3 or 4 bbl. under the boilers of a steam plant than 1 bbl. in a Diesel engine.

Concerning the permanency of the supply of fuel oil, there need not be any misgivings, and the fear that processes of "cracking" petroleum to increase the production of gasoline might seriously restrict the supply of fuel oil is unwarranted also. So far, these processes have left available an ample quantity of oil which it would not pay to crack or which remains after cracking, and which is suitable for Diesel fuel.

In connection with this subject, it may be pertinent to refer to the properties which affect the suitability of a fuel oil for use in a Diesel engine. In the old days, the primitive systems of lubrication and the over-cautiousness, which is natural in connection with unfamiliar ap-

*Abstract of paper presented at Midwest Power Conference, Chicago, Ill., Jan. 26-30, 1926.
†Vice President, Busch-Sulzer Bros., Diesel Engine Co.

paratus, led the builders of Diesel engines to set up quite elaborate specifications for the fuel. Today the limitations have been reduced materially, although even the modern Diesel engine cannot be operated continuously and satisfactorily with every liquid fuel which may be injected into its cylinders.

Fuel for a Diesel must be clean, free from water, and of even more importance is the amount and quality of the ash. The particular type of Diesel engine has nothing to do with the effect of the ash and a fuel should not be used under any circumstances or at any price, if, in the condition in which it is delivered to the engine; that is, after the fuel filtering, the ash content exceeds 0.05 per cent by weight. A limit of 0.02 per cent ash is much to be preferred. Sulphur content may be ignored as fuel oil from this country does not contain enough sulphur to injure the engine. The specific gravity is little more than a general indication of the properties which may be expected, and this determination has been entirely omitted from U. S. Government specifications. Flash point is of importance only as it affects safety in storage and usually will be objectionable only if under 125 deg. F.

Cooling Water Important

Although ordinarily a minor item of expense, the water for cooling the Diesel engine is a matter of importance. In a steam plant the character of the water must be considered as affecting the boilers, heaters and condensers while in a Diesel plant as affecting the jacket spaces and in both plants as an item of cost, whether purchased or pumped. Water which is suitable for use in a boiler is also suitable for use in a Diesel engine, but the reverse is not necessarily true. To some extent, in the case of the Diesel, hardness of the water may be offset by circulating enough to keep its temperature down to a point at which it does not precipitate its impurities.

This is exemplified by the regular use of sea-water in the jackets of marine Diesel engines. Whether for steam or for the Diesel the water must be free from suspended solids, such as mud, sand or leaves which may be removed by settling, skimming and straining. If the water in its raw state is not suitable for use it should be purified or pure water used over and over with purified make-up. In the case of a Diesel plant the water may be cooled for re-use in a simple heat-exchanger, using raw water as the cooling medium or a cooling tower or spray pond may be used. Any one of these will be smaller than similar provisions for condensing water because the cooling for the Diesel is from and to higher temperatures.

Quantity of cooling water circulated through the jackets of a Diesel engine is governed by the load on the engine, the initial temperature of the water, and its permissible discharge temperature. Roughly, it is between 1/6 and 1/10 of that required by a condensing steam plant, under the same load conditions. On the other hand, although the boilers require purer water than is necessary for the Diesel, the condensers can operate satisfactorily with water which should not be used in its raw state in a Diesel engine. .

Formerly to obtain equivalent results it was assumed that a Diesel plant required more highly trained personnel than did a steam plant. Time has proved that there is no difficulty in training an intelligent steam plant operator to be an equally competent Diesel engineer or attendant. The number and class of men in the engine room crew depends upon the number, size, and the periods of operation of each unit or of the whole plant.

Another important operating expense is the cost of lubrication, which is subject to a number of variables. For a Diesel engine plant, the consumption of lubricating oil varies between 1 gal. per 2400 brake hp.-hr. with small units to 1 gal. per 3000 brake hp.-hr. with large units, while the cost of lubrication has been found to be about 1/10 to 1/12 the fuel cost. An equivalent steam engine plant will consume 1/2 to 2/3 of this quantity, while the consumption will be 1/8 to 1/10 in a steam turbine plant.

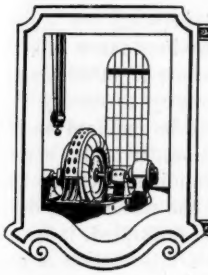
Maintenance of machinery varies between $1.00 per 2500 brake hp.-hr. for small engines to $1.00 per 5000 brake hp.-hr. for large engines. This is substantially the same as for equivalent steam plants including the boilers, being somewhat lower with steam turbines and somewhat higher with steam engines.

Fixed charges comprise allowance for interest, reserves for depreciation and obsolescence, and charges for taxes and insurance. If the other charges are properly made, when comparing different means of power supply, there is no reason for considering extraneous general expenses, which would remain the same regardless of the source of power, although such expenses would have to be included if the purpose of the estimate were to arrive at a cost on which to base the selling price of power. The amounts included to cover the fixed charges presuppose a definite economical and useful life of each of the elements composing the plant. Based upon actual experience, it is safe to assume the useful life of a Diesel engine to be 25 yr.

In calculating fixed charges, care should be exercised to avoid the all too common and misleading error of summing up the fundamental percentage rates and applying the sum to the total investment over the total period of life. Regardless of the disposition of reserves for depreciation, whether in the periodical retirement of bonds, in the creation of a sinking fund, or in extensions or improvements to the plant it is clear that the value of the original tangible assets, originally represented by the investment made in them is reduced each year by the amount of their annual depreciation. Charges for interest, taxes and insurance, therefore, must be reduced proportionately by applying an average percentage rate based upon the entire assumed life and the applicable method of disposing of the reserves.

In the possible requirement of hot water or steam for heating or manufacturing purposes the quality and the periods during which it is required may materially affect the selection of the means of power supply for an industry. For example, the most economical arrangement may prove to be a combination of purchased power and low pressure boiler, a low-priced steam-wasting prime mover, a highly efficient prime mover and low pressure boilers, or a highly efficient prime mover which is capable also of furnishing a limited amount of steam or hot water.

Something is already being done in the utilization of the heat rejected by Diesel engines and more will be accomplished. The temperature of the exhaust gases leaving a Diesel engine is 400 to 700 deg. F., sometimes higher, while the jacket water leaves the engine between 110 deg. and 150 deg. F. Of the total heat value of the fuel consumed, the exhaust gas carries off about one-quarter and the jacket about one-third.

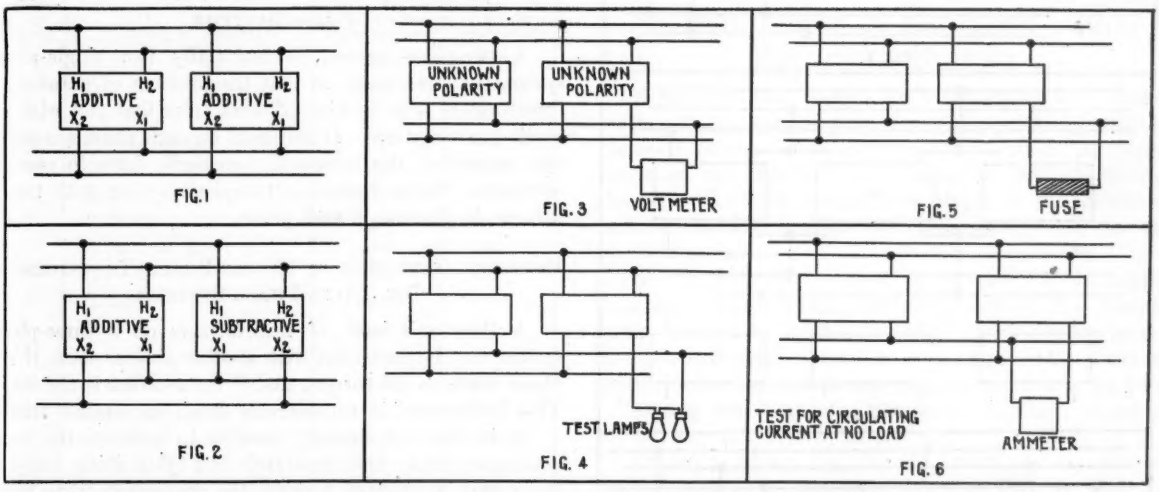


ELECTRICAL MACHINERY FOR LIGHT AND POWER

Principles of Transformer Connections---Part IV

METHODS OF TESTING AND OPERATION OF TRANSFORMERS IN PARALLEL ON SINGLE AND MULTI-PHASE SYSTEMS. BY V. E. JOHNSON

IN OPERATING single or multi-phase transformers in parallel, it is extremely important in connecting them up, that the polarity of the terminals be considered. This has been discussed in the previous articles appearing under this heading.* In this article we will take up in greater detail the general subject of parallel operation.



FIGS. 1-6. DIAGRAMS SHOWING TRANSFORMERS CONNECTED IN PARALLEL AND METHODS OF CHECKING CONNECTIONS

PARALLEL OPERATION OF SINGLE PHASE UNITS

In Fig. 1 are shown two single phase units connected in parallel, the leads being marked in accordance with the Power Club Rules. As is apparent from the relative positions of H_1 and X_1 both of these transformers have additive polarity. Figure 2 shows two transformers having different polarities.

In the absence of information as to the polarity of the transformers to be connected, tests may be made to determine the proper method of joining the leads. Figure 3 shows the use of a voltmeter in making a test of this kind. If the leads are right, the voltage will be zero. On the other hand, if the leads are crossed, the voltmeter will indicate double secondary voltage.

If a voltmeter is not available, test lamps having a normal voltage of double the secondary may be used. This is shown in Fig. 4. If the lamps are dark, the connection may be completed.

Figure 5 shows a third method of determining whether or not the leads may be joined. It consists of making the final connection through a fuse; this will blow if the polarity is wrong. This test is suitable for use on small units, where the rush of current, in the event of an improper connection, would be too small to establish a destructive arc. If applied to large units, especially if the secondary voltage were high, the blowing of the fuse might start a short which would do considerable damage.

If the two units paralleled as above, have exactly the same ratio of turns, there will be no current circulating between them at no load, and an ammeter connected as in Fig. 6 would indicate zero. This condition would exist only if the transformers were connected on similar taps, but would not be affected by the regulation of the units. In other words, an ammeter test would not indicate the results that could be expected under load conditions.

If the two transformers were exactly identical, and were connected on the same taps, the voltage would drop an equal amount on each, when loads were applied, and as a result, the units would divide the currents equally. On the other hand, if the units did not have the same regulation, one would take more than its share. Inasmuch as the terminal voltage on the two units must be the same (being joined through conductors of negligible resistance), the value of the current circulating through the windings will be that required to produce equal drops in both.

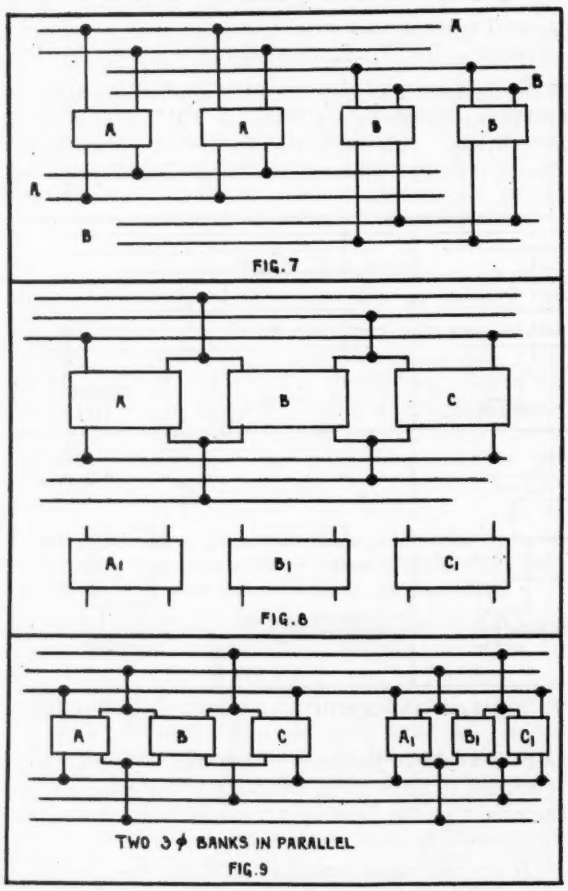
If the transformers did not have exactly the same ratio

*These articles appeared in the following issues of Power Plant Engineering: Sept. 15, 1925, Nov. 1, 1925 and Dec. 1, 1925.

of turns, current would flow as soon as they were connected in parallel, and the ammeter in Fig. 6 would no longer indicate zero. The amount of current flowing would be expressed by the formula I=Ed÷Zs where E_d is the difference of the secondary voltages, and Z_s is the sum of the impedances.

If transformers of different ratings are to be multipled, the total rated capacity can be obtained only if the units have the same per cent impedance. If this is true, the voltage drop will be the same on each, under full load conditions, and both will reach rated load at the same time.

With unequal impedances the unit having the lower



FIGS. 7-9. PARALLEL OPERATION OF TRANSFORMERS ON POLYPHASE SYSTEMS

value will take more current, and will reach its rating first. If several units are multipled, the capacity of the entire bank is reached when any one of the component transformers reaches its limit, for the total load can then not be further increased without overheating that particular one.

If two transformers having unequal impedances, and also dissimilar ratios, are connected in parallel, the capacity of the bank will be still further reduced, for in that case, not only will one unit reach its rating before the others, but both must carry, in addition, a sufficient circulating current to equalize the voltage difference caused by the variation in the turn ratio.

Perfect operation at all loads would theoretically require that the reactance and resistance which make up the impedance be properly proportioned between the units, but the error is extremely small if the impedance is kept correct. In ordering transformers that are to parallel with a given piece of apparatus, it is necessary to specify the impedance. If parallel operation is to be required on all of the taps, and with all coil combinations, it is also necessary to have a development of the winding, showing the number of turns per section, etc. If the name plate data of the unit to be duplicated, or to be multipled, is given (including all reference numbers) this information is obtained from the maker.

The impedance of a transformer is determined by its design, and depends largely upon the arrangement of the primary and secondary coils with reference to each other. It sometimes happens that commercial considerations make it undesirable to obtain the necessary characteristics by these means. It then is customary to use external reactors, of such proportions that, in connection with the internal impedances, they produce the correct division of load.

Parallel Operation of Single-Phase Units on Two-Phase Systems

A two-phase system is essentially two single-phase systems in quadrature, so that the problem of paralleling transformers is in no wise different from that met with on single-phase systems. If the units on each phase are properly connected, the bank will necessarily have to operate correctly. Figure 7 shows a two-phase system with transformers in parallel in each phase.

Parallel Operation of Single-Phase Transformers on Three-Phase Systems

A three-unit bank of transformers on a three-phase system may be paralleled with another similar bank if the phase relations are correct, and if the rotation is the same. This is discussed in considerable detail in another article.

It is, however, entirely possible to consider the units making up each phase separately and by so doing simplify the actual method of making the connection, this being particularly true where the units in question are located near each other. If they are located at a distance, proper tests must be made before the final connection is completed.

In Fig. 8 in a diagram a bank of transformers in delta-delta, to which three more units are to be added in order to increase the capacity. If A is connected in multiple with A_1, B with B_1 and C with C_1, following the procedure laid out for single phase systems, the double bank will be properly formed. The result will be that shown in Fig. 9.

If the six transformers composing this bank are of equal rating, and have the same characteristics, the total bank capacity will be equal to the sum of the ratings. If the characteristics are not the same, or if the capacities are different, the total bank output will be limited by the individual unit which reaches its rating first.

If the units which compose one of the delta-delta banks are dissimilar the rating will be reduced. If the ratios are not the same so that the secondary voltages have different values, a current will flow around the delta, and this will be of a magnitude determined by the difference between them. In addition to this circulating current, there will be an unequal division of load if the impedances of the units have different values.

If the units which compose a delta-delta bank are not of the same size maximum output can be obtained only if all of them reach full load simultaneously. This is true only in cases where the impedances are so proportioned as to cause the loads to divide in direct proportion to the individual ratings. It is sometimes necessary to use external reactors in connection with dissimilar units in a bank in order to reach the highest capacity.

It can be seen from the preceding that a delta-delta bank requires fairly close agreement between the units of which it is composed. Commercially, it is possible to operate when there is considerable difference, but good practice has set a limit of about 10 per cent of normal on the circulating current around the delta at no load. Under load the total current should not be sufficient to overheat

COMBINED RATINGS OF A VARYING NUMBER OF SIMILAR TRANSFORMERS CONNECTED IN DELTA AND OPEN DELTA GROUPS

Number of Units	Method of Connection	Three Phase capacity in percentage of total single phase ratings	Equiv. number of single phase units
2	Λ	86.6	1.75
3	Δ	100.0	3.00
4	ΛΛ	86.6	3.50
4	Δ/ or ΔL	82.0	3.25
5	ΔΛ	80.0	4.00
6	ΔΔ	100.0	6.00
6	ΛΛΛ	86.6	5.25
7	ΔΔ/ or ΔΛJ	91.0	6.5
7	ΔΛΛ	72.0	5.0
8	ΔΔΛ	88.0	7.0
9	ΔΔΔ	100.0	9.0
10	ΔΔΔ/ or ΔΔJΛ	94.0	9.5
10	ΔΔΛΛ	80.0	8.0
11	ΔΔΔΛ	91.0	10.0
12	ΔΔΔΔ	100.0	12.0
13	ΔΔΔΔ \	95.0	12.5
13	ΔΔΔJΛ	95.0	12.5
13	ΔΔΔΛΛ	85.0	11.0

the windings, the percentage of permissible overload being determined by the design, and by the ambient temperature.

In a star-delta bank there can be no circulating current (due to differences in ratio) of a magnitude sufficient to cause heating. Furthermore, differences in impedance do not seriously affect the division of load between the units in the group.

If the banks of transformers to be paralleled are separated by considerable lengths of line so that the resistance is of a reasonably high value, dissimilarity is not of so much consequence, even if comparatively great. On large units involving heavy currents, it frequently happens that a considerable difference in impedance can be fairly well compensated for by the lengths of the cables used for making connections to the bus—even though the actual distances are comparatively small. The same thing would be true with smaller sizes also, except for the fact that under these conditions the leads are usually so large in comparison to the required carrying capacity, that the resistance drop is very low.

It is possible to operate closed delta and open delta banks in parallel and such conditions are often forced by the failure of single units in multipled groups. The solution for the combined capacity depends on the relative sizes and characteristics, and consists fundamentally in considering each phase by itself. Thus phase A might consist of one 25 kv.a. unit, while B and C were each composed of a 25 kv.a. unit and a 15 kv.a. unit. The combined capacities of the 25 kv.a. and 15 kv.a. would be 40 kv.a. if they were similar, otherwise it would be less. Similarly, the bank rating would be reached when the 25 kv.a. in phase A reached its capacity.

With dissimilar units, the greatest total output would be obtained when the available transformers are so grouped as to have the greatest capacity per phase. If the ratings and characteristics were all the same, the greatest capacity would in general be obtained by forming as many three unit groups as possible.

The accompanying table gives the combined ratings of a varying number of similar transformers connected in delta and open delta groups. This tabulation appeared in the "Electric Journal" several years ago.

Savings Banks to Establish Utility Securities Bureau

A FACT-FINDING bureau for investigation and dissemination of information relative to the merits of particular issues of public utility securities, to be under the supervision of the National Association of Mutual Savings Banks is practically assured according to a late announcement of Milton W. Harrison, president of the Savings Banks Journal.

For the first year at least the bureau will be largely financed through advertisements placed in the Savings Banks Journal by prominent public utility companies and investment houses, a certain percentage of the amount raised by the advertisements to be used for that purpose.

Among the companies who have definitely agreed to support the fact-finding bureau are:

Brooklyn Edison Co., North American Co., Electric Bond & Share Co., American Light & Traction Co., Associated Gas & Electric Co., General Electric Co., Blodget & Co., Stone & Webster, Guaranty Trust Co., Hodenpyl, Hardy & Co., Halsey, Stuart & Co., Harris, Forbes & Co., Coffin & Burr, Dillon, Read & Co., Utility Securities Co., Public Service Corporation of New Jersey.

A statement from Mr. Harrison says in part:

"For two successive conventions, the Committee on Public Utilities of the National Association of Mutual Savings Banks has emphatically placed before the convention the real merit of utility bonds, and has necessarily pointed out the lack of information from independent sources concerning the public utility industry, upon which institutions could base their request for necessary legislation which would give them the right to invest in public utility bonds and to broaden their field of investment, and has pointed out the necessity for having such information to guide their investment."

AN AUTOMATIC stop valve is just as much a necessary safety device for a boiler as a safety valve. And an automatic valve doesn't cost over 5 per cent more than an ordinary stop valve of like size. Then, considered as safety insurance, the investment in a good automatic valve for each boiler is about as much for the money as could be had in almost any other way.

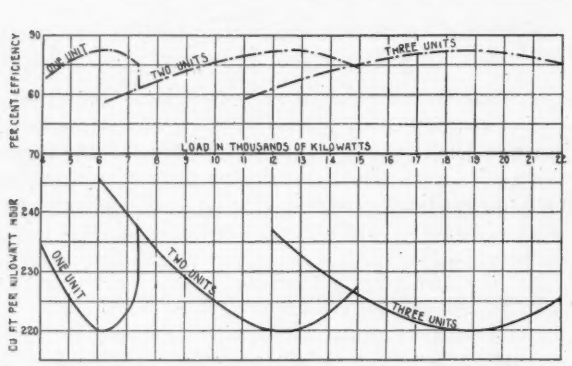
Suggestions Regarding Hydraulic Plant Operation

PARALLEL OPERATION WITH STEAM PLANTS. BY L. F. HARZA*

A VAST amount of study has been devoted to the subject of operation of steam stations to insure maximum fuel economy, because of the evident importance of fuel economy to steam power costs.

On the other hand, operation of hydro-electric plants has not, in general, been given the amount of study and intelligent supervision necessary to obtain not only the maximum energy output from a given installation but also the maximum service to the system as a whole that its importance deserves. The same intelligent supervision should be given to hydraulic plant operation, and with such supervision the output and usefulness of a hydraulic plant should in general be appreciably increased.

Hydraulic power stations differ so greatly in their characteristics and capabilities that no general conclusions can be drawn. In many low-head plants, where the head is entirely destroyed in time of flood, the stations must be



LOAD-EFFICIENCY CHARACTERISTICS OF A PLANT CONTAINING THREE 9400-KV.A. UNITS AT 220-FT. HEAD

justified largely upon a coal saving basis. Assuming, however, a dependable hydro-electric project, having at least a portion of its capacity of dependable prime supply, then this station can perform certain service for the system more economically than steam, independently of its absence of fuel cost.

It is said that the capital cost of a hydro-electric plant is so much larger than the capital cost of a steam plant, that the increased fixed charges tend more or less to offset the reduced operating costs arising from the lack of fuel requirements. This statement, however, is very misleading in some respects.

It is the cost of the dam, overflowed lands, bridges, highway changes and various similar items that causes the cost of a hydro-electric plant to exceed the cost of a steam plant. Having already provided a dam with all of its incidental costs, then the strictly power generating station with its intakes, penstocks, machinery and building substructure and superstructure can be built more cheaply than a steam station per unit of capacity for heads of about 25 ft. or greater, assuming the capital investment in the steam station to be $125 per kilowatt. For a head of 50 ft., the hydraulic generating station costs only about two-thirds of the cost of a steam station and for a head of 100 ft., costs less than half as much, based of course upon general average conditions, since two sites are never identical.

If a hydraulic station is justified on the basis of its energy output at system load factor on a competitive basis with the average steam cost of a given system, then this hydraulic station can be provided with excess capacity for serving peak loads at less than system load factor more cheaply than the steam capacity of the system can be increased for peak load service. In other words, instead of the general opinion that a hydraulic plant must suffer from higher fixed charges, the fact is that an increase in capacity of the hydraulic system above that required for base load can be secured often at considerably less investment cost than an increase in steam capacity, and at the same time will require no fuel cost for its operation.

Now the cost of serving the peak load of the system is not 6 mills or 8 mills or 1 cent per kw-hr. by steam but is usually much greater than this. The shorter the duration of the peak load on the system, the smaller is the load factor of the equipment installed to serve this peak load and the higher the proportionate fixed charges, as well as fuel consumption per kw-hr. applied to the energy generated during the peak. It is in this field that the dependable hydro-electric project can accomplish the greatest good to a steam system. On the other hand, a hydraulic station equipped to utilize, during the peak load hours, the entire water supply of its dry season will usually, during wet seasons of the year, have water enough to run continuously, perhaps at its full capacity, thus displacing base load capacity at other than peak load hours and thereby reducing the load factor on the steam plant during such times, to the disadvantage of the latter's unit cost of energy.

Ideal equipment of a hydraulic station for maximum service then consists of multiplication of capacity to the limit of available water supply and available daily storage, for the purpose of carrying as much as possible of the daily peak of the system during the low water or dry season of the river and the use of this capacity to the limit of available water supply during high water seasons, to the exclusion of an equivalent amount of steam capacity. This subject has been enlarged upon in a very able paper by F. A. Allner, Member of the American Society of Mechanical Engineers, in a paper entitled "Parallel Operation of Hydro and Steam Plants", September, 1925 issue of Mechanical Engineering, and will not be further considered here. The principal point which I want to emphasize is the reverse of the usual opinion; namely, that additional capacity of hydraulic power for heads above 25 ft. at least, is usually cheaper in first cost of installation than steam power, after construction of the initial structures, a point which Mr. Allner did not bring out.

Now in the combined operation of steam and hydraulic systems, conflict and jealousies frequently arise, unless the operation is under one head. This head must be a man of remarkable impartiality and in continuous hourly contact, through the load dispatcher, with the conditions existing on the entire system. The operator of every steam plant on the system is naturally anxious to produce as big an output and to maintain as good a load factor on his station as possible and thereby make the best showing to his superior on unit costs of production. A hydraulic

*Consulting Engineer, Chicago. Presented at the Midwest Power Conference, Chicago, Jan. 27, 1926.

plant fitting into the same system interferes more or less with these ambitions and may at times increase the unit costs. Thus in a period of surplus water, it is of general economy to the system to utilize the hydraulic plants to the maximum extent of available water supply, yet to do so may not only reduce the operating capacity but also the load factor and thereby increase the unit costs of parallel steam stations, although reducing the total operating costs of the system. At such times, the steam plant operator must yield to the greater good of the system and in general can only be induced to do so by the superior authority of a load dispatcher who has in mind the total operating costs of the system rather than the economical showing of various units thereof.

In connection with a recent request on the part of the Hydraulic Power Committee, N. E. L. A., for statistics regarding reliability and operating efficiency of hydro-electric power units, I was impressed with the meagerness of available data. Many companies do not seem to appreciate the value of complete operating records and the fact that these records can, in general, be obtained at little and usually at no cost whatsoever. The switchboard operator of a hydraulic station ordinarily has little work to occupy his time, a condition having a very bad psychological effect, as tending to cause him to relapse into a mentally sluggish mood, from which he recovers but slowly in an emergency demanding his attention. The more nearly the duties of the operator serve to occupy his entire time, the more alert will he be when alertness is needed. The making of systematic records of all that transpires in the station accomplishes a valuable purpose and requires no increase in operating force.

Records of headwater elevation, tailwater elevation and flow of the river at a hydraulic plant are very useful for planning developments above or below, for enlarging of the existing station, as well as for determining modifications and improvements justified or necessary in the existing station for maximum economy.

It is surprising how few hydraulic stations, at least in the Middle West, record hourly or more frequent computations of the total flow passing a given station, through the turbines, through the flood gates, over the spillway or elsewhere. Every hydraulic station should be equipped with curves giving the relation between kilowatt load per unit and discharge in cubic feet per second throughout the entire range of head, determined from actual tests in place, if possible, or otherwise from the Holyoke tests or manufacturers' guarantees. The record of hourly load in kilowatts on each unit should be accompanied by a computation, made at that time from the curves, of the cubic feet per second being used by the unit and recorded in a parallel column. Such procedure not only accumulates useful data for future reference but also impresses continually upon the operator the importance of operation at correct load and the fact that by so doing he can obtain more kilowatt hours with the same amount of water. It educates him in the matter of economical operation for maximum kilowatt hours, with the minimum consumption of water.

Curves should also be available of the discharge capacity of all flood gates or waste gates at all degrees of opening and records should be made of the position of all gates and computations kept up to date continually by the operator, of the water discharged by them; likewise by any free overflow at the spillway.

At one time I was called upon to reconstruct an obsolete station and was told that a considerable increase in capacity over the original installation was justified, as water was wasted over the spillway for a large portion of the time. The old station had operated over 10 yr. and practically no records had been kept which would serve as a guide as to the variable operating head or the amount of water which had been wasted and for what portion of the year by which I could intelligently determine the justified installation of the reconstructed station. This is not an exceptional condition. It is frequent, especially in low-head and small power plants throughout the Middle West.

The N. E. L. A. Committee has asked for statistical data from existing plants regarding reliability of hydro-electric units and calling for a list of outages and their causes. In my opinion outages should be recorded by the operator and classified under the following heads:

Outages for routine maintenance, 6 hr. or less.

Outages for routine maintenance, 6 hr. to 24 hr. in duration.

Emergency outages and their duration.

The turbine may be shut down for cleaning grass or weeds from the regulating gates or to facilitate raking the trash racks. It may be shut down for periodical inspection of the runner clearances and for various other purposes, for which an opportune time can be chosen, such as that of light-load hours, say from midnight until 6 a.m., or, if a longer time is required, a Sunday can be chosen when the load on the entire system is low. Such outages do not affect the reliability of the unit. Time of the shutdown can be chosen at will but all such outages should, nevertheless, be recorded on the daily log sheet, indicating purpose and time required. Emergency outages with their cause and time involved are, of course, of more importance and should be fully written up on the daily log sheet or by special report.

Prediction of Flow

For operation of a hydro-electric station for maximum output and economy, the operator should be fully informed as to river stages upstream from the station and as to probable weather conditions. Local forecasts are generally furnished by the U. S. Weather Bureau stations for 24 hr. or more in advance and general forecasts can be furnished for nearly a week in advance. In addition, rain gages and river gages should be installed at intervals above the existing development and daily or even more frequent reports by telephone or wire should be obtained by the operator from which to predict flow of the stream as far ahead as possible, for his use in governing the operation procedure. For example, the approach of a rise should, in certain types of developments, dictate the drawing down of the upper pool level by heavy operation, in order to provide some storage volume for the expected rise. If this were not done, the rise could be utilized only to the extent of the capacity of the station, whereas by drawing down the pool in advance of the rise, the kilowatt hours of storage thus provided constitute a net addition to the output of the station.

The operator should check each predicted rise against the experienced rise, thus gradually educating his judgment or evolving a formula for such predictions. There are many other features of operation requiring an intimate knowledge of turbine hydraulics and hydrology of the watershed as well as intelligence of the highest degree for successful application for maximum output. Too often hydraulic plants are left in the hands of the cheapest class

of operators, which practice cannot be too strongly condemned. Money invested in intelligent supervision will in general pay a very large return.

Power Factor Correction

Hydraulic units during periods of low stream flow can often be used as synchronous condensers for power factor correction. This is frequently done by maintaining a gate opening of the turbine sufficient to operate the unit at synchronous speed, but it should never be done, as the waste of water is considerable. It is best to bring the unit up to speed by the turbine gates and, when the unit is on the line, to close the turbine gates, allowing the generator to operate as a motor. If properly equipped for lubrication of the guide bearing and runner seals, it is then best also to drain the penstock and vent the draft tube so that the unit will roll with least resistance as a synchronous motor.

Where it is contemplated that a new installation will, at times, be used for power factor correction, either it should be equipped with convenient head gates and separate system of lubrication of the turbine guide bearing and water supply for the seal rings to permit draining of the scroll case and consequent venting of draft tube or, in lieu thereof, it can be equipped only with a vent for the draft tube without draining the scroll case, so that only the leakage water of the regulating gates will be wasted during operation as a condenser.

Automatic Stations

Within recent years, automatic and semi-automatic stations have made their appearance and have been applied principally to small stations up to as high as 7500 kw. These stations have operated with a degree of success, dependent largely upon the state of development of the relays. These relays have been continually improved until successful automatic operation is a proven fact.

Success of automatic stations leads the writer to suggest and advocate the extension of some of the principles used in automatic operation to larger stations manually operated in order to insure greater reliability of operation and reduced operating force. I have in mind that the human operator frequently does the wrong thing or, in any event, is much slower to act in time of emergency than an automatic relay. At times a relay may fail to function, through dull contacts or otherwise, yet it is likely to be much more reliable under emergencies than dependence upon the human factor. It is our belief that many of the protective features used in automatic stations could well be adopted for manual stations and that even self-synchronizing for manual stations would be a distinct advance and preferable to manual synchronizing. It would probably not be practical to pull large units into step as synchronous motors, the field coming on afterward, as is usually done in small automatic stations. Equipment has, however, been developed and applied in two American stations for self-synchronizing, using the same sequence of events as in manual synchronizing; namely, by first throwing on the field, and afterward the main circuit breaker at the instant when the speed becomes exactly synchronized, as determined by a differential speed device, one speed being operated from the bus and one from the generator leads. This system is understood to bring in a unit with remarkable smoothness and without disturbance on the line. Such a principle is applicable to units of any size and would eliminate the personal equation in synchronizing and also permit synchronizing in a shorter length of time.

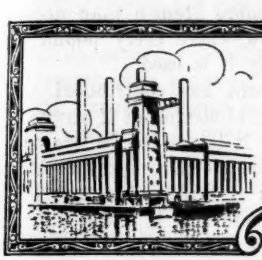
One-Man Station

As an approach toward the automatic station for those of larger size, the writer has so designed his stations as to permit every operating gesture to be done from within reach or within sight of the switchboard, leaving only maintenance to be done elsewhere. It has been our custom to build the switchboard floor at the elevation of the walkway around the exciter on top of the generator and also to bring all oil piping, water cooling pipes, etc., in loops to sight flow indicators above the elevation of this switchboard floor and visible from the switchboard. The operator is then able to observe the collector rings, the commutator brushes, the flow of cooling water for the bearing or lubricating oil, temperature of thrust bearing, and other similar features from the switchboard or by departing only a few steps from the switchboard and without leaving the elevation of the switchboard floor. We have found it convenient to install the turbine governors directly in front of the switchboard, driving the fly-balls by motor from potential transformers installed on the generator leads and also providing hand operation of the turbine gates in the form of a hydraulic pump immediately adjacent to the governors and in front of the switchboard, thus permitting a unit to be entirely started, even on hand operation, and all observations and adjustments on it to be made from the switchboard and by the switchboard operator.

These ideas have been worked out with the purpose of developing what I choose to call a one-man station, that is, a station which requires only one man per shift for strictly operating duties. The plan would be to divide the day into three shifts of 9 hr. each overlapping one hour. Each operator would come on duty 1 hr. before his predecessor leaves the board. He would spend this hour in an inspection of the condition of all equipment, noting, in an appropriate place on the log sheet, all facts which he had observed and would then take over the switchboard and station, after having inspected all features thereof and with a full knowledge of their condition and what maintenance work should be done.

For a station which does not experience severe ice or trash rack troubles and where equipment is of modern low maintenance type, it is probably sufficient to provide for a maintenance man on the day shift only, this being the nearest approach to the automatic station. In some stations, perhaps one man on each shift would be required, the off-shift men to be subject to call for emergencies.

The most difficult maintenance feature to organize is that of raking the trash racks in plants where severe ice and trash troubles are experienced. This is partly a seasonal demand which adds to the difficulty. The writer is familiar with one wood pulp mill which shuts down completely about one hour during each shift at some seasons of the year and turns the entire operating force onto the gate platform to rake the trash racks. For a hydro-electric plant adjoining this station, the writer once developed an electrically operated mechanical rake, cleaning a width of 10 ft. of trash rack at one lift, which has proved able to rake a depth of 30 ft. of trash racks across a length of 270 ft. in about 1 hr. requiring only two men to operate. It has been in operation 8 yr. It is believed that the matter of mechanical raking is one feature of hydro-electric operation which has not been given the study which the subject deserves and the lack of it has unnecessarily increased the difficulties of operation and the troubles in properly organizing the operating force.



LETTERS DIRECT FROM THE PLANT

Power Plants Are Too Noisy

When you step into a modern power plant, one of the first impressions you get—if you are not an operating man and accustomed to it—is the noise of operation. You attempt to talk to the man beside you, find it necessary to yell into his ear, and usually what you say is misunderstood. At any rate, the reply is likely to be a nod or a shake of the head, indicating a full understanding or entire agreement with your remarks. It has ever been a mystery that men are willing to work under conditions where their ear drums are continually vibrating from discordant sound waves, and the question naturally arises whether all the noise in a power plant is really necessary. Generally it is not. Take for example the item of steam escaping from any source whatever. Much that is being done for better economy today is the stopping of unnecessary steam leaks. Operators are instructed to prevent the safety valves on boilers from blowing off, to keep packing joints tight, to repair leaky valves, and to prevent the escape of hot water and exhaust steam. All of these items mean waste, and they are being prevented more and more each year.

Noise means vibration, and vibration in the power plant means energy wasted. To accomplish their objectives, the past generation used reciprocating motions, but today most machinery tends towards rotary prime movers. This change was made primarily for economy both of space and power; however, it has also resulted—fortunately for everyone concerned—in quieter machinery. In other words, the gain in economy has usually meant a lessening of vibration.

One step further brings us to the ball and roller bearing in contrast with the older babbited or bushed bearing. There again is a lessening of noise and vibration. Is it not possible, then, for us to assume, in a general way, that wherever we lessen the noise of an operation, we gain in the amount of energy required to perform it? Compare the turbine with the reciprocating steam or gas engine; the centrifugal pump with the reciprocating type; the old ratchet type drive for traveling grate stokers with the modern motor or water turbine-driven unit. Smoke used to be considered an indication of industry. Today, it is universally recognized as an indication of waste. Some day, perhaps, the whirr of the wheels of industry will be considered in the same light.

Is it not possible, then, to imagine that some day our designs of power generating apparatus will be so perfected that they will operate with much less or very little noise? This may mean changes in the diameters of rotating parts or perhaps raising or lowering the velocities of air, water and steam flow. It follows logically, therefore, that our designs are faulty wherever we find excessive vibration. The early automobile was noisy; the modern car is a beautiful, quiet running machine of still higher power. Why not keep before our eyes the vision of a future power plant where the energy of coal, gas or oil will be converted into electrical energy economically but quietly and without such unnecessary straining and stressing of human beings and materials? Let us have ideals and vision in engineering just as the chemist, the sculptor, the painter and the architect work toward their ideals which lift us out of the drudgery of everyday life.

Cleveland, Ohio. Walter G. Stephan.

Boiler Drums Show Different Water Levels

Engineers who have had boilers with two or three longitudinal drums have no doubt experienced some difference in water level between the drums. The writer, while visiting a plant one morning recently, found the engineer much perplexed about the water in one of his boilers. I think it would put any man in the same state, if he spent 2 hr. on his water columns and found all to be in good condition, but still had a difference of 7 in. between the water level in the two drums of this particular boiler.

When I asked the engineer to what he ascribed his trouble, he said: "I don't know, unless the repair man left the back vertical tubes covered with the sacks he used when cleaning the boiler." His surmise was found to be almost correct, when the boiler was examined the next morning.

Readers may recall that in the issue of Aug. 1, 1925, p. 811, a description was given of the method used at this particular plant to circulate air through the boiler drums for the comfort of a man cleaning the inside.

Some of the caps are taken off the back headers, the manhole doors removed and sacks or other such material placed over the upper ends of the rear verticals. The stack damper is then opened and current of air is brought in through the manhole, along the drums, down the front verticals and back along through the tubes to the stack.

Now, when a boiler is to be cleaned, both manhole doors are taken off, but since only one drum is cleaned at a time, to get all air possible, the boiler cleaner closes the manhole of the drum that he is not in by pushing into it a sack half filled with waste. This is done because the doors are heavy and the sack of waste is handled much more easily.

In this particular boiler, the engineer claimed, the workman either forgot to remove the sacks that lay over the verticals in the right-hand drum, or the sack that he used for blocking the manhole was pulled in with the stack draft. Investigation showed the latter.

When the boiler was taken off, the half-filled sack was found covering five of the rear vertical tubes, thus causing the water circulation to be so far reduced that

the water was frequently 7 in. higher than in the left-hand drum.

It is really a wonder how the boiler escaped injury, doing 150 per cent of rating for 5 hr. with no circulation through more than one quarter of the boiler.

Wabana, Newfoundland. J. B. PETRIE.

Engineers' Requests Must Show Savings

IT OFTEN happens that the engineer in charge of a plant gets the idea that it is useless to ask for new equipment, since his requests are usually disregarded by the manager.

It is the writer's experience that much depends on how the request is made. If it is merely in the nature of a statement to the effect that No. 2 engine is a pile of junk and ought to be replaced by a steam turbine, the manager may agree that such a course would be a fine one to pursue if business were better and pass to some other subject. If, however, the engineer will take the time to prepare a report showing real savings or show the return on the investment, the average manager generally will give him an audience. It is simply a matter of considering the question from the manager's viewpoint.

Almost any average plant houses misfit equipment of one kind or another, although still in operating condition, and would cost considerable to replace with more efficient units. If, as is seldom the case, money is no consideration, it is a simple matter to make a general cleanup. But since, normally, the average plant does not maintain a reserve sufficient to carry out such a program, the problem resolves itself into a careful consideration of what replacements will yield the highest returns.

It is, therefore, only fair that before getting a pronounced grouch over his inability to obtain some coveted replacement, the engineer should present his argument as forcibly and convincingly as possible; unless he does so, he has no right to feel that his department is being slighted.

Lincoln, N. H. A. P. NUTTER.

Steam Flow Meter Advantages

IT IS OFTEN learned after installing steam flow meters that entirely too much steam is used in certain departments of the plant. Faults are thereby corrected and the meter pays for itself almost instantly. Without meters the existence of large and costly leaks cannot be easily detected.

Paradoxical as it may sound, many times it has been found profitable to install a steam flow meter only to learn that it doesn't pay to use steam at all. Thus if a plant is consuming considerable steam in one department and the manager is not certain about the profitableness of the steam, a meter should be installed. The meter will give the facts. Then, if the meter shows positively that electrical operation would be better than steam, the use of steam should be abandoned and electrical equipment installed in its place. Although by so doing the steam flow meter eliminates its own use, it is nevertheless good business and good engineering to do so.

Roughly, every six pounds of steam wasted is equivalent to one pound of coal wasted plus the cost of production of the steam. Save the steam and you save coal, labor and equipment. Even where fuel is cheap, it is poor business to install more boilers and use more firemen than necessary. It invariably pays to know where every pound of steam goes and how economically it is used.

Modern boiler room equipment has contributed admirably to the cheaper production of steam but if no check is kept on its consumption after it leaves the boilers and it is wastefully used, of what value are the improvements? If all of the steam is wasted, it is evident that the improvements are of no value whatever. If no steam is wasted, the full advantages of the improvements are realized and only then. We can, therefore, truly say that the advantage of high boiler efficiency is directly proportional to the economy of steam used.

Surely, with all the effort and engineering ability that is being and has been expended on boiler plants to generate more steam per pound of coal, serious attention should be given to the use of the steam. Flow meters are the best means of collecting data for an accounting system applied to a boiler plant.

Newark, N. J. W. F. SCHAPHORST.

Inspector Rules Out Boiler Welding

REFERRING to the issue of Dec. 15, 1925, p. 1282, the writer was interested in reading S. W. Miller's article on the welding of boilers.

In this connection, the writer recently had a case in which the bottom drum of a Stirling boiler was badly grooved just below where the tubes enter the drum. The local boiler inspector for the insurance company, as well as the head inspector for the entire district in which the boiler was located, was friendly to us and inclined to be fair in every way, but when the writer proposed to fill up the groove by electric welding and put in plenty of additional metal so as to make this place in the drum amply strong, both inspectors stated that the rules of their insurance company absolutely prohibited the use of welding in boilers. The writer can readily understand why this would be so with acetylene welding, but cannot see why a good electric welding job would not be practical.

The only other remedy in this case was to replace the drum with a new one or take a reduced pressure on the boiler.

It is the writer's impression that all of the boiler companies have similar rulings. A valuable service would be rendered to the engineering profession if a statement could be obtained from the boiler insurance companies as to the conditions under which they would permit making repairs to boiler shells or drums by welding.

Chicago, Ill. C. P. BARNETT.

Editor's Note—Following Mr. Barnett's suggestion, letters were sent to several insurance companies. Replies, for the most part, were in agreement, each quoting from various state boiler codes or from the A.S.M.E. Code from which most state codes are obtained. Replies from three companies, which will be listed as A, B and C, are given herewith and following these statements we quote the rules which insurance companies have adopted concerning autogenous welding:

A. Mr. Barnett certainly does not understand the dangers involved in the use of autogenous welding in boiler structures, for if he did, he certainly would not propose to make a repair such as indicated in his letter. A repair of that kind, as far as we know, would be absolutely unacceptable to any insurance company. The very fact that a groove has occurred shows that the material where the

groove is located has been stressed higher than other points in the vicinity of the groove and it would certainly be a most dangerous proceeding to attempt building up the surface at such a groove with any idea that the strength of the structure would be improved. It would be exceedingly dangerous to operate a boiler with any such repair.

B. There are conditions under which we have no objection to welding in making repairs of boilers. In regard to the case mentioned, if the grooving extended for any considerable length and reduced the thickness of the plate to a point where its strength was less than the tube ligaments, welding should not have been employed, as it would not add to the strength of the plate, but would merely act as a filler and protection against further grooving.

C. Rules of this company must necessarily conform with the boiler rules in the several states and locations that have adopted and enforce boiler laws and ordinances. While most of these are in agreement (excepting Massachusetts), there are some minor differences; but the states of Pennsylvania, New York, Ohio and New Jersey are fairly representative of what is regarded as safe, conservative practices in the repair of power steam boilers by autogenous welding.

It is our understanding that most, if not all, boiler insurance companies are guided by these rules, which are effective by law in the several states above mentioned.

Requirements for Autogenous Welding

By "autogenous welding" is meant any form of welding by fusion; that is, where the metal of the parts is to be joined or added metal used for the purpose is melted and flowed together to form the weld. Such welding is accomplished by the oxy-acetylene, hydrogen or other flame processes, or by the electric arc; no distinction is made between any of those processes. The general rule to govern the acceptance of such welds in insured vessels is that prescribed by the Boiler Code of the American Society of Mechanical Engineers, Par. 186, as follows:

"Autogenous welding may be used in boilers in cases where the strain is carried by other construction which conforms to the requirements of the Code, and where the safety of the structure is not dependent upon the strength of the welds."

The following illustrations will serve to point out where such work should be accepted or rejected.

1. Any autogenous weld of reasonable length will be permitted in a staybolted surface or one adequately stayed by other means so that should the weld fail, the parts would be held together by the stays. It is necessary for the inspector to use judgment in interpreting the meaning of "reasonable length" as given above, since it may vary in different cases. In the average case it should be not more than 3 ft. Autogenous welding will not be accepted in unsupported surface.

2. The edges of the inner and outer sheets of vertical firebox boilers or boilers of the locomotive type may be joined by autogenous welding to form the door openings, if the surrounding surfaces are thoroughly stayed. This would also apply to other openings of a similar character in such surfaces.

3. For low pressure plate steel boilers operated at a pressure not exceeding 15 lb. per sq. in., or for higher pressures in unfired vessels subjected to water pressure only, rectangular headers may be autogenously welded at the edges if the sheets are properly held together by stays. Autogenous welding of cracks and fractures in cast-iron boilers will not be permitted.

4. Fire cracks in girth seams extending from the edge of the plate to the rivet hole may be autogenously welded, provided the cracks are properly prepared by cutting out the metal at the crack in the form of a letter "V," to permit fusion through the entire thickness of the plates. Similar cracks in girth seams located between the rivet holes may also be autogenously welded, provided the cracks do not extend beyond the edge of the lap of the inner plate. In the latter class of cracks it is advisable to drill a hole not exceeding ⅜ in. in diameter at the end of the crack before the weld is made. Cracks extending from rivet hole to rivet hole on girth seams cannot be welded. Calking edges of girth seams may be built up by autogenous welding under the following conditions: The original section of the metal between rivet holes and calking edge to be built up must average equivalent to ¼ of the diameter of the rivet hole and the portion of calking edge to be replaced must not exceed 30 in. in length in a girthwise direction. In all repairs to girth seams by autogenous welding, the rivets must be removed over the portions to be welded and for a distance of at least 6 in. at each end beyond such portions. After repairs are made, the rivet holes should be reamed before the rivets are redriven.

5. Stayed sheets, which have corroded to a depth of not more than 40 per cent of their original thickness, may be reinforced or built up by autogenous welding. In such cases the stays shall come completely through the reinforcing metal so as to be plainly visible to the inspector.

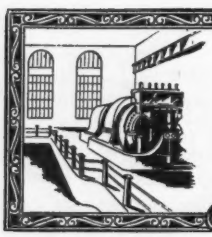
6. Where tubes enter flat surfaces and the tube sheets have been corroded or where cracks exist between the tube ligaments autogenous welding may be used to reinforce or repair such defects. The ends of such tubes may be autogenously welded to the tube sheets. The above-mentioned repairs for tube sheets and the welding in of tubes in the sheets are not to be permitted where such sheets form the shell of a drum or boiler, such as in the case of Stirling type of boiler.

7. When external corrosion has reduced the thickness of plate around handholes to not more than 50 per cent of the original thickness and for a distance not exceeding 2 in. from the edge of the hole, the plate may be built up by autogenous welding.

8. Pipe lines will be accepted where the flanges or other connections have been welded autogenously, provided the work has been performed by a reputable manufacturer and the parts properly annealed before being placed in position. Such welding when made with the part in place and un-annealed, will not be acceptable.

9. Autogenous welding in patches in the shell of a boiler will not be acceptable regardless of the size of such patches. Autogenous welding of cracks in the shell of a boiler—except those specified in Par. 4—regardless of the direction in which they may lie—will not be permitted, unless such welding is only for the purpose of securing tightness and the stresses on the parts are fully cared for by properly riveted-on patches or straps placed over the weld. The plates at the ends of joints may be welded together for tightness, provided the straps or other construction is ample to care for the stresses on the parts so welded.

10. Re-ending or piecing of tubes for either fire-tube or water-tube boilers by the autogenous process will not be permitted.



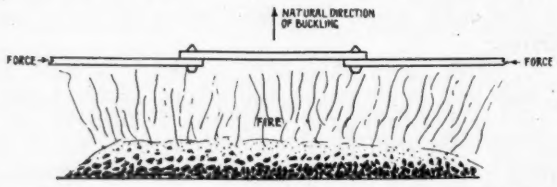
QUESTIONS AND ANSWERS

Boiler Plates Bowed Up by Oil on Tubes

REFERRING to the inquiry of W. E. S., page 167 of the issue of Jan. 15, although complete details are not given, my analysis is as follows:

Most of the oil was deposited on the bottom of the tubes and for that reason the bottoms became hotter and weaker than the tops, and therefore, due to compression, the tubes were caused to buckle upward, following the direction of least resistance.

In the meantime, since the boiler shell was clean, the shell transmitted heat better than the tubes and did not expand as much, thus causing the tubes to protrude through the tube plates. With the cooling down of the boiler, the contraction of the tubes was slightly more than the contraction of the shell and because of the buckling of the tubes, the combined forces set up by the contraction of all the tubes was too great for the shell to resist and it buckled in its own direction of least resistance.



METHOD OF RIVETING BOILER PLATES DETERMINES DIRECTION OF BUCKLING

The fire beneath the boiler made no difference as to the direction of buckling; it merely caused an expansion or lengthening of the plates. The direction probably was caused by the method employed in riveting the boiler. If the sheets lapped in such a way that the ends are larger in diameter than the center of the boiler by twice the thickness of the metal, a "couple" would be formed as shown in the accompanying sketch and the tendency would be to buckle inward.

Newark, N. J. W. F. SCHAPHORST.

Explosions in Compressed Air Lines

Is COMPRESSED air inflammable, or what is it that causes explosions in air lines? What should be done to prevent it? W. B. B.

A. Compressed air is not inflammable, but during compression by mechanical means, it is found advisable to use oil, and this oil, or the gases from it, are the sources of combustion. In most cases firing may be traced to the use of poor oil, but in others too much oil sometimes causes ignition.

It is a common mistake of engineers in charge of compressors to feed oil too rapidly to the air cylinder. It is only necessary to supply sufficient oil to keep the interior of the cylinder and the moving parts moistened. In equipment where steam is used, there is a tendency to cut away the oil. For this reason engineers grow accustomed to feeding a larger supply than is required in an air cylinder where there is nothing to cut or absorb the oil and it is only after a considerable lapse of time that it can get away after being fed to the cylinder. There is no washing tendency as with steam, and a drop now and then is all that is required to keep the parts lubricated. Where too much oil is used, there is a gradual accumulation of carbon, which interferes with the free movement of the valves and chokes the passages, so that momentarily a high temperature may be formed and ignition follow. It is well to get the best oil and use sparingly.

Explosions have been caused by the introduction of kerosene or naphtha into the air cylinder for the purpose of cleaning the valves and cutting away the carbon deposits. Every engineer knows how easily he may clean his hands by washing them in kerosene, and, as this oil usually is available, engineers often introduce it into the air cylinder through a squirt-can at the inlet valve. This is an effective way of cleaning valves and pipes, but it is a source of danger, and should be forbidden. High-grade lubricating oils are carefully freed of all traces of benzine, naphtha, kerosene and other volatile distillates. The inflammability of the latter is so acute that it is a dangerous experiment to introduce anything of this kind into an air cylinder, and if any of our readers have had an explosion in a case where the engineer uses kerosene, it may be traced to this source. Closed inlet passages leading to the air cylinder through which free air is drawn from outside the building have many advantages, but the best probably is the interference with the tendency of the engineer to squirt kerosene into the cylinder.

Soft-soap and water is a good cleanser for the air cylinder, and is recommended even in cases where the best oil is used. Long service will result in more or less accumulation of carbon and dust drawn in with the air and it is therefore advisable, once or twice a week or oftener, if necessary, to fill the oil cup with soft-soap and water and feed it into the cylinder as the oil is fed. Be sure to use *soft* and not *hard* soap, for when the water evaporates, if the latter is used, it may mix with the carbon and dust to form a hard ball in the air line.

It is apparent that the cause of an explosion is an increase of temperature above the flash point of the oil which is used to lubricate the compressor. A thick or cheap grade of cylinder oil should never be used in an air compressor. Thin oil having a high flash point, and which is as free from carbon as conditions of lubrication will permit, is best.

As a remedy for explosions we would suggest more care in selecting the best air compressor and in frequent cleanings of the discharge valves and passages. The best

air compressors are built so that the discharge valves may be removed easily; these valves should be cleaned regularly and the engineer should make sure that they fit properly. Often it is difficult to get good lubricating oil free from carbon, hence there may be more or less carbon deposited on the discharge valves, but this must not be allowed to accumulate.

Intercoolers between air cylinders and after-coolers between final cylinder and receiver are also recommended. The best intercoolers are made of nests of brass tubes, with the air passing around the tubes and the water through them. This stirs up the air thoroughly and permits efficient cooling. One of these coolers located in the discharge pipe will prevent the passage of flame and will insure protection against an explosion, even though there be ignition at or near the air cylinder.

Standards for Water Hardness

IN OUR feed water treating plant we have been using soda ash and lime and have been testing hardness with a certain standard soap solution in which 1 c.c. of soap solution in 100 c.c. of treated water equals 1 grain of hardness per gallon.

Recently we ordered a new stock of standard soap solution which apparently is of a different standard since the label on the bottle reads 1 c.c. = 0.001 gm. $CACO_3$. We find that this new solution will not check with the old. What correction must be made in order to measure the hardness in grains per gallon as formerly? T. F. M.

A. If your original soap solution was such that 1 c.c. in 100 c.c. of treated water equaled 1 grain of hardness per gallon, it would be classified as the American Standard. Since your new soap solution is such that 1 c.c. equals 0.001 gm. calcium carbonate ($CACO_3$) per 100 gm. of water, it may be classified as the French Standard.

The following are the various standards of hardness used in different countries:

French—Milligrams of calcium carbonate in 100 gm. of water or, parts per 100,000 of water.

German—Milligrams of lime in 100 gm. of water or, parts per 100,000 of water.

English—Grains of calcium carbonate per "imperial" gallon of 70,000 grains.

American—Grains of calcium carbonate per "U. S." gallon of 58,381 grains.

Your new standard is the same as saying that a given number of parts of soap solution is equivalent to the same number of parts of calcium carbonate per 100,000 parts of water. Parts per 100,000 divided by 1.714 = grains per U. S. gallon, which is the former standard you were using.

To give a specific example: If with your new soap solution you find you have used, say, 8 c.c. in 100 c.c. of treated water, then, if you divide this figure of 8 by 1.714, you will get the number of grains per U. S. gallon. This figure of 1.714 is obtained as follows:

$$1 \text{ lb.} = 7000 \text{ grains}$$
$$1 \text{ gal.} = 8.33 \text{ lb.}$$
$$\frac{1}{8.33} \times 100{,}000 \div 7000 = 1.714$$

The term "grains per gallon" is usually used among chemists more than among engineers and the expression "number of parts per 100,000" is more generally used. This means that if you have a hardness of 8 parts per 100,000, there is 8 lb. of scale forming material per 100,000 lb. of water. Or, if we put it the other way, 8 divided by 1.714 = 4.66 grains of scale forming material per gallon of your treated water.

To avoid confusion it is often better to make up your own standard soap solution which may be made as follows: Dissolve 13 gm. of sodium oleate in 500 c.c. of 96 per cent alcohol and add 500 c.c. of water. This ought to give the right strength, but the sodium oleate may vary somewhat, and to make sure, it is best to test out the soap solution with a standard hard water.

Standard hard water is made by dissolving 1.11 gm. of chemically pure calcium chloride (Iceland spar) in 1 liter of distilled water. Now to test the soap solution we measure 58.3 c.c. of pure distilled water into a bottle, put into it 12 c.c. of the standard hard water. Then from a measuring tube add soap solution, ½ c.c. at a time, shaking the bottle well after each dose of the soap solution. The hard water is neutralized when a lather is formed about ¼ in. deep which will last for 5 min. with the bottle lying on the side.

It should take just 13 c.c. of the soap solution and if less is required, it indicates that the soap solution is too strong and should be diluted with pure distilled water until it takes exactly 13 c.c. of the soap solution to give the permanent lather; if neutralizing takes more than 13 c.c., it will be necessary to dissolve a little more sodium oleate in alcohol and put it into the soap solution.

Boiler Rating and Actual Evaporation

HAVING two similar boilers carrying the same load in boiler horsepower, one operating at 75 lb. gage pressure and the other at 125 lb. gage pressure, which boiler will be evaporating the greater amount of water? J. A. L.

A. Your question is not specific enough since it does not state the feed water temperature for each boiler. If we assume the same feed water temperature for each boiler, then it is merely a matter of determining the factor of evaporation, since a boiler horsepower is based on the evaporation of water from and at 212 deg. F.

This factor may be calculated from the following formula:

$$F = \frac{H - h}{970.4}$$

where, F = factor of evaporation; H = total heat in steam; h = sensible heat in feed water above 32 deg.

If we assume a feed water temperature of 200 deg. for each boiler, then with the 75-lb. boiler: H = 1184 B.t.u.; h = 168 deg.; F = 1.047. With the 125-lb. boiler: H = 1192 B.t.u.; h = 168 deg.; F = 1.055.

Now, since a boiler horsepower is the evaporation of 34.5 lb. of water from and at 212 deg., then dividing 34.5 by 1.047, we get the actual evaporation of the 75-lb. boiler, which, in this case, is 33 lb. of water. With the 125 lb. boiler we get 34.5 ÷ 1.055 = 32.7 lb. water, so that the 75-lb. boiler is evaporating more water than the 125-lb. boiler. If, however, we were to assume 200 deg. feed water temperature with the 125-lb. boiler and only 100 deg. feed water temperature with the 75-lb. boiler, then the 125-lb. boiler would still have an actual evaporation of 32.7, whereas the 75-lb. boiler would only have an actual evaporation of 30.0 lb., since the factor of evaporation would be 1.149.

It may be seen, therefore, that a great deal depends on the feed water temperature and that this is just as important as the boiler pressure.

Midwest Power Conference

FROM THE OPENING ADDRESS BY SAMUEL INSULL TO THE CLOSING MEETING, THE CONFERENCE WAS ONE OF ENLIGHTENMENT, INSPIRATION AND PLANS FOR FUTURE POWER DEVELOPMENT IN THE MIDDLE WEST

IN SPITE of the extremely cold weather, the Midwest Power Conference, held at the American Exposition Palace in Chicago on January 26 to 29 was well attended by the leading engineers in the Mississippi Valley, the official registration being 1193. The Conference was arranged as a joint sectional meeting of the American Institute of Electrical Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers, National Electric Light Association and The National Safety Council. W. L. Abbott, President of the American Society of Mechanical Engineers, was chairman of the opening meeting held on Tuesday and introduced Samuel Insull, head of the Commonwealth Edison Co., and many other power interests throughout the United States.

PROMINENT ENGINEERS WHO TOOK PART IN THE MIDWEST POWER CONFERENCE

James H. Harron, Cleveland; C. F. Hirshfeld, Detroit; L. F. Harza, Chicago; W. L. Abbott, Chicago; H. Birchard Taylor, Philadelphia; B. L. Lyons, Chicago; D. W. Mead, Madison.

In his address, which is printed on other pages of this issue, Mr. Insull told of his coming to Chicago in 1892 to assume the presidency of the Chicago Edison Co., which, through expansion, took on the competing power companies in the Chicago district and became the Commonwealth Edison Co. He outlined the resources of the Mississippi Valley and quoted paragraphs from various speeches made from the time of his coming to Chicago to the present day, which indicated his growing confidence in the extent to which electric power could be used. He also gave statistics on power developments and needs upon which he bases plans for future development of the industry.

At the Wednesday morning session, the principal topic of discussion had to do with hydro-electric developments and at this meeting B. F. Lyons, of Chicago, President of the Great Lakes Section of the National Electric Light Association, was chairman. Daniel W. Mead, consulting engineer of Madison, Wis., delivered a paper on "Water Power Resources of the United States," an abstract of which will appear in an early issue of Power Plant Engineering. He stated that the various ways of expressing power resources of the country or the capacity of undeveloped water power sites and of expressing the extent of development on streams where power plants have been installed are so numerous and so different that any figures given are likely to be misunderstood or misinterpreted.

Mr. Mead spoke of the factors which enter into the rating of streams, such as the fall of the stream, the topography of the community, the head available, stream flow, which in turn depends upon the rainfall, its occurrence and distribution, area, topography, geology, soil conditions, vegetation, temperature, etc. In many streams the total annual flow of high flow years is more than double the total annual flow of low flow years and the highest and lowest flows can be determined only after many years' observation.

In estimating the potential water powers of the United States the practicability of the immediate development of powers cannot be considered for, if it were considered, there would be eliminated at once a large percentage of all the undeveloped powers of the United States which cannot be developed at the present time on account of one or more of the following reasons:

1. Lack of market within practicable transmission distance.
2. Excessive expense of development.
3. Legal restrictions and entanglements.

Mr. Mead does not anticipate any great acceleration of the rate of development in the future, inasmuch as in most cases the developed powers available each year are

farther from the market and are more expensive to develop.

"Changing Viewpoints in Hydraulic Turbine Practice" was the next paper on the program, which was read by H. Birchard Taylor, President of the Pelton Water Wheel Co., Philadelphia, Pa. For 20 yr. Mr. Taylor has been active in the development and improvement of hydraulic turbines and in his paper he gave a brief review of the progress made during that period. His subject was divided into a discussion of the hydraulic and mechanical features of design. In early designs two principles were stressed: the avoidance in all portions of the turbine conduit of sudden changes in section which would cause the flow to form eddies or to break up into turbulence; and avoidance of high velocities in the conduit, in order to reduce the losses due to skin friction. Time and experience have proved that the first is of greater importance in design. The flow of water should utilize effectively the full areas provided along the conduit. All of the notable improvements made during the past few years in elbow type draft tubes came about through the elimination of eddy losses.

One of the outstanding developments in the art of hydraulic turbine design took place about the years 1911 and 1912 when the vertical single runner turbines suddenly came into prominence.

With the building of units of large capacity and the necessity for pressing the bucket bolts into place, there has been developed the plan for making the entire bucket rings removable from the wheel bodies so that repairs can be made as quickly as possible.

Mr. Taylor closed with the statement that now every new hydraulic plant is, to a considerable degree, experimental—the conditions are hardly ever twice alike in all their variables—and often the design which seems the most "conservative" involves the greatest unrecognized risks.

L. F. Harza, consulting engineer of Chicago, presented a paper entitled "Suggestions Regarding Hydro Plant Operation," which appears in full on other pages of this issue.

R. F. Schuchardt, electrical engineer of the Commonwealth Edison Co., was called upon for a few remarks on the subject of superpower and pointed to the economies possible by generating electric current in a few large plants as compared to a large number of small plants.

"Extension of Power Service to Rural Communities" was the title of the paper read by G. C. Neff, Vice-president of the Wisconsin Power & Light Co., and chairman of the Rural Electric Service Committee of the N.E.L.A. The speaker pointed out how the availability of power had influenced the development of our country from the pioneer days to the present. Villages and cities have grown to depend on public utilities which are now extending their services to the farms. Up to the present time power has been supplied on the farm very largely by horses, steam engines, gasoline engines and windmills. The American farmer uses several times as much power and machinery per worker as the farmers of Germany, France, Italy and Great Britain. If we would increase the standard of living of the American farmer, it is necessary to make it possible for him further to use power and machinery. Rural electric service is going ahead. Thousands of farms are being connected every month and the rate of increase in connections is growing each year. A serious effort is being made to guide the development work along sound economic lines, building step by step on facts now known and on new facts as fast as they are proven in the field laboratories now in active operation.

This paper was discussed by E. H. Lehmann, Professor of Farm Mechanics, University of Ill., and Dr. E. A. White, Director of the Committee on Relation of Electricity to Agriculture.

At the Wednesday afternoon session the discussion was on topics particularly interesting to power plant operators. A paper by Wm. S. Monroe, President of Sargent & Lundy, Chicago, Illinois, gave a complete story of the history and the development of power house construction in the Chicago district. Beginning with the early history of power house construction, he followed with present developments, showing some of the features of the design of the Crawford Avenue Station, and then gave a glimpse of what may be expected for the future of electric power development in the Chicago district. An abstract of Mr. Monroe's paper, giving the salient features in more detail, will appear in an early issue.

Pulverized Fuel Important

Methods of burning pulverized fuel are now of prime importance to power plant operators. C. F. Hirshfeld, of the Detroit Edison Company, discussed the development of pulverized fuel practice, as applied to boiler firing, touched on a few of the main features of operation at present and ventured a few surmises of what may happen in the near future. Impetus to pulverized fuel burning was given with the development of the air cooled refractory wall. Following this came the water cooled wall, which brought this method of firing into even greater favor, as it removed one of the greatest handicaps. Experiments are now being conducted in the use of more rapid methods of burning pulverized fuel, all striving to effect such intimate mixtures of air and fuel that smaller furnaces may be used. Smaller furnaces mean smaller investments and since cost is an important item, this must be reduced to a minimum if pulverized fuel is to reach the highest point of success. Mr. Hirshfeld pointed out that at present there seems to be a tendency among operators to believe that pulverized fuel burning will solve all combustion problems, regardless of the conditions involved. He warned against too much optimism.

In many cases the choice between the centralized fuel system and the unit system will depend on a number of local conditions, but Mr. Hirshfeld stated that in most cases the unit mill will take precedence over the centralized system.

In contrasting pulverized fuel firing with stoker firing, he pointed out the merits of each method and stated that in a recent study of actual operating costs in both stoker fired and pulverized fuel fired plants it was shown that when using high grades of eastern bituminous coal the cost of producing steam was practically the same with both methods. This analysis showed, however, that as the coal becomes poorer and poorer in quality the advantage of burning in pulverized form becomes greater and greater, when measured in the actual cost of steam. Pulverized fuel firing has the advantage of flexibility with respect to the variation in the character of the coal and also greater flexibility in changes of load. One of the most serious disadvantages of pulverized fuel firing which must be overcome as quickly as possible, is the ash nuisance. In many cases, excessive quantities of ash

are discharged from the stack. Equipment for eliminating this trouble is now being developed and improved, but much more remains to be done. Pulverized fuel, properly adapted, will serve to solve a great many difficult fuel problems, but Mr. Hirshfeld emphasized the point that engineers should combine common sense and business judgment and not jump at conclusions too rapidly.

An interesting discussion of Mr. Hirshfeld's talk was led by Henry Kreisinger of the Combustion Engineering Corporation. Mr. Kreisinger believes that, as applied to the larger boilers, the central system has greater value than the unit or direct fired system, since a boiler must have more than one mill if reliable operation is to be assured. Mr. Kreisinger explained that the reason pulverized fuel furnaces were at first built so large was to keep the walls away from the flames. Since the refractory walls had to be kept out of the zone of high temperature and the flames were not allowed to impinge to get intimate mixing, there had to be slower combustion and, of a consequence, larger furnaces. With the introduction of water cooled walls, more violent mixing could be employed, combustion effected quicker and therefore the furnaces could be made much smaller. Mr. Kreisinger stated that as better means of mixing are devised it may be possible, when using water cooled walls, to reduce the present size of furnaces 25 per cent. It is difficult, however, to make any definite statement.

Low Temperature Carbonization Offers Economy

Following this discussion a paper on "The By-Product Processing of Coal" was read by H. W. Brooks, of the Fuller-Lehigh Co. By-product processing may be divided into six classifications:

1. Extraction by solvents; 2. Conversion of coal into oil by hydrogenation; 3. Conversion of coal or carbides into oil by gas synthesis; 4. Complete gassification; 5. High temperature carbonization; 6. Low temperature carbonization.

Of these methods, the first is of little commercial value, while the next two give considerable promise, but as yet have not had sufficient development on an industrial scale to warrant much prophesying. Complete gasification has certain merits, but it is difficult to see how it may be of direct benefit to power plant operators except under special circumstances. Of more immediate promise to the power plant operator are the fifth and sixth classifications—high and low temperature carbonization. Experiments have shown that the latter is likely to be more economical, hence more profitable to the power plant operator. A complete discussion of low temperature carbonization was given by Mr. Brooks in the Nov. 15, 1925, issue of Power Plant Engineering.

Boiler Water Needs Scientific Treatment

Boiler water treatment is also of interest to power plant operators and in a paper read by Dr. R. E. Hall, Physical Chemist of the U. S. Bureau of Mines, many important phases of this subject were discussed. The responsibility in boiler water conditioning includes more than clean surfaces. Corrosion in feed lines, economizer and the boiler is a function of the condition of the water and must be controlled. Steam lines and turbine blading deposits must be obviated by the system of conditioning. By the chemical treatment employed, the amount and character of non-condensible gases in the steam must be controlled in accordance with the intended use of the steam. Responsibility in boiler water conditioning does not end with the entrance of the water into the boiler, but with the passage from the boiler nozzle of steam, the dryness and purity of which are defined by the uses to be made thereof. Besides the prevention of scale formation on evaporating surfaces on feed water lines and preheating sections, there must be control of non-condensible gases in the steam. In general, the necessity for controlling the concentration of dioxide in the steam arises most frequently. For such control the obvious thing to do is to keep all carbonates as far as possible from the boiler water.

Control of sludges and soluble salts in the boiler water, their relation to wet steam and the removal of any boiler water and its suspended insoluble material from the steam before it leaves the boiler nozzle are as integral parts of any complete system of boiler water conditioning as the factors which have been mentioned. Particular methods of treatment and the chemical equations involved will be discussed in a more complete abstract of Dr. Hall's paper to appear in an early issue. A discussion of this paper, prepared by J. D. Yoder, of the Cochrane Corp., was read by A. L. Rice.

At the Thursday morning session Paul L. Battey read a paper on "The Layout and Equipment of Industrial Power Plants," emphasizing load factor as having the greatest bearing on the type of equipment.

G. B. Warren and J. H. Keenan, research engineers of the General Electric Co., presented an interesting discussion of their paper, describing a machine for testing steam turbine nozzles by the reaction method. This paper explains in detail the apparatus used in reaction nozzle tests, difficulties encountered and the methods of obtaining and developing test data. This paper has been printed by the American Society of Mechanical Engineers and may be obtained by application to the Secretary.

Coal Mines Purchase Power

Most of the coal mines in Illinois purchase their power, rather than attempt to generate it themselves. One of the principal reasons given by J. Paul Clayton in his paper on "Purchased Power for Coal Mines in Illinois" was the fact that the water supply in the vicinity of these mines is often limited. Low load factor due to operation of the mines for only brief periods in the last year was also given as a reason.

One of the interesting features of Thursday's session was a paper on "Safety and First Aid in Industrial Plants," presented by C. B. Scott, President of the National Safety Council. Following Mr. Scott's paper a demonstration of first aid service was given by a team from the Public Service Co. of Northern Illinois.

J. A. Emery and Gen. Keller Address Dinner Meeting on Thursday Evening

At the dinner on Thursday evening, which was held in the dining room of the Furniture Club of America, the principal speakers were J. A. Emery, Vice-president of Ford, Bacon and Davis, and Gen. Charles Keller, of the Byllesby Engineering and Management Co. Charles Piez, Chairman of the Board, Link-Belt Co., officiated as toastmaster.

Mr. Emery outlined in a general way the broad importance of power development in the civilized world and showed how much more power the individual of today has at his command than his ancestors of a few generations ago. He also discussed briefly the probable effect of our tremendous power development upon human happi-

ness. In spite of all the comforts and conveniences which modern civilization gives us, are we, asked Mr. Emery, any happier than our forefathers who did not possess these things? As the amount of power per capita increases, man obtains more leisure. The question is, therefore, will he employ this greater leisure in improving himself mentally and spiritually, thereby insuring still further progress, or will he, by wasting these increased leisure hours, permit civilization to decline? While Mr. Emery made no attempt to answer this question, he seemed to be hopeful.

Gen. Keller's paper, which followed Mr. Emery's, was entitled "The Place of Power Availability in National Preparedness." This paper, which was quite lengthy, reviewed in more or less detail the work of the power group of the War Industries Board and showed the importance of such an organization in any scheme of industrial preparedness. The purpose of this power group was to straighten out power tangles in industrial communities engaged in the manufacture of munitions and to allocate blocks of power to various industries and to various communities so as to serve the best interests of the nation. Gen. Keller's intimate connection with this work enabled him to present an illuminating view of the entire situation.

Oil and Gas Session on Friday

For many years past and probably for years to come, oil will play an important part in power plant practice. Friday's session was entirely devoted to oil and gas. Diesel engines are coming into use in the industries and a paper discussing this topic, prepared by Max Rotter of Busch-Sulzer Bros. Diesel Engine Co., was read by a colleague of Mr. Rotter's in the absence of the latter. A detailed abstract of Mr. Rotter's paper appears elsewhere in this issue.

Diesel engines are not only confined to stationary practice, but are being used more and more on locomotives. Samuel M. Vauclain, President of the Baldwin Locomotive Works, presented a paper on "The Diesel Electric Locomotive, Its Present Status and Performance and Its Future Possibilities." Mr. Vauclain's presentation of the possibilities of the Diesel Engine in railroad practice gives an inkling of what may also be done in stationary practice.

Oil Is a Specialized Fuel

Owing to the absence of Allen F. Brewer, who had prepared a paper on "The Economics of Oil as a Boiler Fuel," a brief abstract of Mr. Brewer's paper was given by A. L. Rice, Chairman of the Executive Committee. Mr. Brewer pointed out that since oil is a specialized fuel and there is doubt as to the future supply, we should not use it promiscuously and should burn it only in places where it is difficult to obtain or to utilize coal. Where conditions warrant and it is used as fuel for boilers, oil may be conserved by proper preheating, accuracy in air control, cleanliness of heating surfaces and the prevention of leaks in the oil lines. One of the points emphasized by Mr. Brewer was the matter of oil specifications. Too many owners and operators place undue emphasis on rigid specifications for purchasing. In so doing they compel the oil merchants to furnish them with a much better and more expensive grade of oil than they really need. The adaptability of certain grades of oil to a particular furnace cannot be determined by rigid specifications. To get the best results, the power plant owner or operator should take the oil salesman into his confidence, show him what his power needs are and then make use of the salesman's judgment.

Application of gas to industries was discussed briefly by H. H. Clark of the Peoples Gas, Light and Coke Co., whose paper was presented by Mr. Greenleaf.

Buffalo General Electric Co. to Add 60,000-Kw. Turbine

RAPIDLY increasing load supplied by the Niagara system and the necessity of maintaining a proper balance in the supply of steam and hydro-power have made it necessary to add a 60,000-kw. turbine to the equipment of the River Station of the Buffalo General Electric Co. The construction schedule calls for the new unit to be in operation early in the fall of 1926.

This new unit will be rated 60,000 kw., 66,667 kv.a., 90 per cent power factor, three phase, 25 cycles, 12,000 v. and will operate at a steam pressure of 250 lb. gage, 250 deg. superheat, and one inch absolute back pressure. It is a single unit machine, operated at 1500 r.p.m. The River Station at present includes three 20,000-kw. and one 35,000-kw. turbine generators. These, as well as the large unit now to be added, are of General Electric manufacture.

Direct-connected to the generator terminals will be a three-phase auto-transformer of the same rating. This auto-transformer, which will also be supplied by the General Electric Co., and will have a higher rating and greater physical dimensions than any transformer now in use in this country. Power received from the generator at 12,000 v. will be stepped up by this auto-transformer to 24,500 v., at which voltage it will be fed into the Buffalo General Electric distribution system. Through step-up transformers already in service, connection will also be made at 60,000 v. with the distribution network of the Niagara Power system.

The auto-transformer is a type WCT, water-cooled, with an output of 66,667 kv.a., and with an equivalent transformer capacity of 34,000 kv.a. The efficiencies, which are well over 99 per cent for practically all loads, are exceptionally high considering that this is a 25-cycle transformer. The enormous size of the unit is shown in the following table of dimensions:

Floor space	20 ft. by 13 ft.
Height over conservator	21 ft.
Weight of copper and iron	54 t.
Total weight	120 t.
Amount of oil	10,300 gal.
Length of cooling coil	0.65 mi.
Total length of copper wire	38½ mi.

The size of this machine can also be appreciated when it is compared with a 60-cycle unit. Such an auto-transformer containing the same amount of material as the 25-cycle unit would be capable of delivering approximately 135,000 kv.a., which is equivalent to a straight transformer capacity of over 70,000 kv.a.

Merger plans are being arranged by the Georgia Railway & Power Co., Atlanta, Ga., and the Southeastern Power & Light Co., operating in this same section. The consolidation will include the expansion in present generating facilities and extensions in transmission lines for interchange of power between the two interests. Additional substations will also be built.

EDITORIAL COMMENT

A Look Into Our Power Needs

Those who attended the Midwest Power Conference were impressed with the vision given them not only of the size of the present power development and distribution but of the great demands now being made for power and what the future will require. Greatly increased utilization of electric power on the farms is already taking place and electrification of trunk line railways is being seriously considered. The Middle West is growing rapidly in population and all kinds of manufacturing industries are seeking opportunities offered in this section of the country to expand their activities.

Will those engaged in the power industry permit the demands for power to be supplied by haphazard developments here, there and everywhere as has been done too extensively in the past, or will there be a concerted effort to co-ordinate power developments so as to take advantage of natural surroundings and make the plants the most economical that the science of engineering can devise? In his speech at the opening meeting of the Conference, Mr. Insull stated that the public utility companies find it a fundamental financial and technical advantage to connect up their systems and operate them, in many cases, as if they were a co-ordinated system.

Although electric power generation and distribution is a comparatively new and changing industry, it is old enough to have demonstrated some of its usefulness to mankind and a look into our present and possible future power needs should inspire confidence in every man connected with the industry. The field seems almost unlimited, the unsolved problems are numerous so we have a long way to go before the industry reaches a limit.

Bureau of Mines Co-operates with Carnegie Institute

Engineers in the field of power often lose sight of the fact that all of our plants, from the smallest industrials to the largest super power stations would not exist if it were not for iron and steel and the coal and coke which make steel production possible.

There is scarcely a piece of equipment in the power plant which does not have at least some part made of steel. To further improve steel production the Carnegie Institute of Technology at Pittsburgh has established a Department of Mining and Metallurgical Engineering which is to co-operate with the ferrous metallurgy section of the Bureau of Mines described in this issue.

Directly adjacent to the Bureau of Mines, is located the great technical school founded by Andrew Carnegie. Coal and coke, as well as iron and steel, made possible both this great institution and the Bureau of Mines. One of the largest boiler manufacturers, several steel companies and two power companies have contributed to a fellowship fund at this college.

We may realize the wisdom of locating these great institutions in the Pittsburgh district when we learn that within a radius of 30 mi. the annual production of pig-iron is 8½ million tons, equal to more than 20 per cent of the country's total. Steel production in this district is 11½ million tons annually, equal to 26 per cent of the country's total.

Coal production is proportionately large, 20 per cent of our annual production coming from the Pittsburgh bed alone. Besides this there is an annual production of 11½ million tons of coke, a large part of which is used in producing our greatest commodity, steel.

Natural gas has played an important part in the industrial life of Pittsburgh and the Bureau of Mines, through its gas laboratory, has made many important investigations in gas problems. Industries in a single year have consumed as much as 50 billion cubic feet of gas which in heating power is equivalent to more than 3,000,000 t. of coal.

In defining the nature of the Bureau of Mines' activities, it might be classified as public service work. In this work the Bureau performs two functions: (1) It acts as a sort of clearing house for technical information. This information is collected from various sources, compiled, and then disseminated through governmental publications and the technical press. The Bureau also answers many letters asking for data or advice and always is glad to discuss the technical problems, whether of individuals or organization. (2) The Bureau conducts research, especially research bearing on fundamental principles and laws.

Co-operation is also desired in the actual conduct of the research. This co-operation may take various forms: Sometimes it is merely an interchange of ideas; often it consists of permission for the Government engineers to use industrial equipment for tests; or again, it may take the form of financial assistance to eke out the Government allowance, thus making possible the acquisition of additional apparatus or personnel, which in turn makes possible the undertaking of a study that otherwise could not be considered.

Can Better Engineers Relieve City Congestion

Not long ago, a magazine editorial pointed out that the only possible answer to the problem of the big city is better engineers, quoting the statement of a prominent educator to that effect. It was pointed out that growth of urban population has resulted in the crowding of people into more congested regions where they must place absolute dependence on continuity of service, water, fuel, electricity, communication, transportation and public works. Such congestion has an important bearing on the social and economic progress of the people concerned and the opinion was expressed that engineers, and power engineers in particular, must be trained to pay more attention to human well-being of the city population in order to reach a proper solution of their power problems.

It would seem, however, that the plea for better edu-

cation of engineers to deal with congestion of our great cities is simply a plea for treatment of the symptom rather than for the underlying ailment. If we can get at the cause of this congestion of great cities and make plans to remove the cause as we go along, it seems to us that here is a work of far greater scope for the engineer.

The causes of the problems enumerated above are somewhat complicated, but the remedy is not hard to see and it is even now being tried. It consists in planning cities on a much smaller scale than they now are and planning them to contain a definite number of inhabitants and industries. Industry can be de-centralized and there is a strong and increasingly rapid movement in that direction at the present time. In other words, regional planning, rather than city planning.

Those who are familiar with the present condition of the shoe manufacturing industry in New England know how it has spread into small villages and towns instead of congregating in the larger cities, solely because of improved electric power facilities and the good transportation afforded by the concrete road and automobile truck.

It is in de-centralization of industry and the breaking away of groups of people from the crowded city, to form smaller, scientifically-planned communities, that we see the best hope for the future. True, we must train engineers in our colleges and in our industries to relieve the big city situation. We should not forget, however, that even while we are treating the symptom, we can take steps to remove the cause of the disease, if we are willing to break away from tradition and use the means we now have at our disposal. In this work the power engineer has already played a prominent part. In our opinion, he is destined to play in the future a still more important role in the de-centralization process that must come, we feel, if the congestion of the big city, with its admitted evils and its relatively few advantages, is to be stopped.

Off Duty

Huxtree! Huxtree! Scientists discover new death-dealing cosmic ray! Huxtree! Read all about it in today's Bla-bla Gazette!

In some such manner were we informed several months ago of Dr. Millikan's discovery of a new form of radiation which, it was said, was one hundred times more powerful than X-rays. This latter fact, of course, appealed to the newspapers and in the headlines it immediately became a "death-dealing" ray, to the immense satisfaction, no doubt, of the circulation department. Death-dealing headlines are the very life blood of the newspaper's circulation.

However, now that the excitement has subsided, just for our own information let us see what it was all about. What is this cosmic ray of Millikan's? It is rather a long story but we shall try to explain it as briefly as we can.

The story starts some 20 years back, in 1903 when two physicists, Sir Ernest Rutherford and J. C. McClennan noticed an unaccountable effect on their electroscopes. An electroscope, you will recall, is the little bottle-like affair we used in the high school laboratory to see whether or not a body was electrified. If the ball at the top of the bottle was brought near a charged body, the two gold leaves inside the bottle would fly apart.

Well, to resume our story, these two Englishmen found that when their electroscope was charged, the charge leaked away more rapidly than could be accounted for by leakage through the insulation.

Now, a scientist is a peculiar animal. Whenever he notices something that he can't explain, he gets it into his head that there must be a reason for it and he immediately starts to hunt for the cause. A foolish attribute, to be sure, for what good does it do him to worry about such things which obviously cannot contribute anything to his peace of mind either here or hereafter? However, that is another subject; the main thing is he does worry about it and many times he actually finds what he is after.

So these Englishmen, running true to form, tried to find out what happened to their electroscopes, and while they were unsuccessful, they soon suspected the nature of the trouble. It was well known that when X-rays are permitted to pass through air in the vicinity of an electroscope the instrument rapidly loses its charge. In other words, X-rays have the property of rendering the air conducting and therefore of discharging an electroscope.

It seemed, then, that some unknown rays were present which without making themselves manifest in any other way discharged the electroscope. At first they thought that the mysterious radiation came from the earth but experiments in mine shafts soon shattered that theory. Others took up the problem.

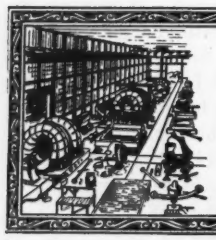
Dr. Millikan finally tackled the problem and his work, which extended over a decade, culminated last summer in a series of beautiful experiments first at Muir Lake (11,800 ft. high), a charming body of water hundreds of feet deep just under the brow of Mt. Whitney and later at Arrowhead Lake, 300 mi. from Lake Muir 7000 ft. lower and equally deep. These experiments brought to light a cosmic radiation of such extraordinary penetrating power that the charge on electroscopes lowered in the waters of the lake kept decreasing until a depth of 45 ft. below the surface was reached. In other words, these rays coming from out in space were so penetrating that it required 45 ft. of water and an atmosphere equal to 23 ft. of water to stop them. This is the equivalent of 6 ft. of lead.

The most penetrating X-rays which we produce in our hospitals cannot pass through a half inch of lead. Yet, here were rays originating somewhere out in space that could go through 6 ft. of lead—a hundred times more penetrating than the hardest X-ray we can produce in the laboratory. High penetrating power in X-rays means simply high frequency or short wave length, and these waves have a wave length of one ten-millionth that of light.

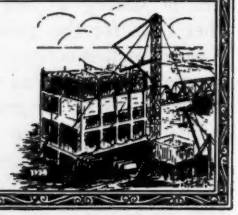
Where do they come from? What causes them? What can they be used for?

Well, they come from out in space, that we know, but as to what causes them we can only guess. The most penetrating X-rays are due to the spontaneous disintegration of radium, so we conclude that these far more penetrating rays are also due to some such transformation enormously more energetic than those occurring in radium. Far out in space, millions, perhaps hundreds of millions of light years away, in some incandescent sun or in the swirling dust of nebulae, atoms undergoing nuclear changes may be the source of these waves. That is only a guess but not at all an impossible one.

What can they be used for? Heaven only knows, we don't—even Millikan doesn't. But that doesn't matter. When Joseph Thomson first noticed the cathode ray, it didn't seem of much use either but today we have the vacuum tube and radio. Some day we may find a use for them; in the meantime the spiritualists and psychists will find great use for them in explaining all sorts of telepathic phenomena. They need something like that.



POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS



Chicago Power Show Arouses Great Interest

VISITING ENGINEERS FIND MUCH OF VALUE IN EXHIBITS OF BOILER HOUSE EQUIPMENT, ELECTRIC MOTORS AND SWITCHGEAR, MECHANICAL TRANSMISSION AND MANY OTHER ITEMS

FROM JAN. 26 to Jan. 30, co-incident with the Midwest Power Conference, the first Midwestern Engineering Exposition was held in the American Exposition Palace, Furniture Mart, 666 Lake Shore Drive, Chicago, Ill. The exposition, the first Power Show held in Chicago, was pronounced a distinct success not only by the engineers who visited it but by the manufacturers who exhibited equipment there. About 60,000 sq. ft. of floor space, all on one floor, was occupied by 212 companies occupying 300 booths. A feature of special interest was the official opening of the exposition at noon on Tuesday, Jan. 26, by Secretary of Commerce, Herbert Hoover, who pressed a button in Washington which rang a large gong in the exhibition hall.

Equipment for the boiler room predominated among the exhibits, although several types of small steam turbines for mechanical drive and two small steam engines attracted considerable attention. Water and air-cooled furnace walls were displayed in many types. Combustion control systems were shown by working models in full operation and many unit pulverizers and stokers of various types were on display. Refractories claimed their share of attention. Valves for pressures as high as 1500 lb. were shown and one display for 1000 deg. temperature service was of interest. Piping and fittings were attractively displayed in many new types for high pressures and temperatures, together with several new and improved types of steam traps. The internal combustion engine was represented by a two-cylinder solid injection Diesel engine.

Electrical equipment of new and improved types included an interesting armorclad switchgear, a new electric household refrigerator and a new type of sealed sleeve motor bearing. Improvements in motor construction, both electrical and mechanical, were noted. Electric motor drives and controls for steam and water valves proved interesting and there were several exhibits of circuit breakers and switching equipment for outdoor substations featured by special types of contacts, motor operation and the like.

Industrial plant engineers were especially interested in the attractive exhibits of gears, mechanical drives and ball and roller bearings, which were presented mostly in the form of working models.

COAL BURNING EQUIPMENT

Bethlehem Steel Co. exhibited a model of its new pulverizing mill. This consists essentially of a heavy cast-iron framework enclosing a horizontal table, which rotates slowly beneath crushing rollers and is surmounted by an adjustable air separation chamber. Material to be pulverized flows by gravity to the center of the table, whence the centrifugal action spreads it outward in a thin layer over the tracks on which the rollers revolve. A current of air induced by the exhaust fan sweeps up over the edge of the table, carrying the pulverized material up.

Interest at the booth of Fuller-Lehigh Co. was centered on the small gas fired model of the recently developed well-type furnace. This was set up with 4 burners producing a centrifugal turbulent action and gave some idea of what might be expected in a large furnace of this type. A working model of the Fuller-Kinyon conveying system for pulverized coal and other pulverized material was also displayed. A model Fuller-Kinyon pump took pulverized material from the hopper, passed it through pipe lines, which were controlled by small automatic switching valves, and returned it to the hopper. Sections of the pipe were of glass to show the flow of material.

Erie City Iron Works displayed one of its small unit pulverizers showing the feeder construction and the arrangement of the rotor. In the latter two pulverizing stages are used and a fan is mounted on the shaft to draw the pulverized material through.

The Strong Scott Mfg. Co. called attention to its Unipulvo system for coal pulverizing and burning equipment. Around the rotor chamber is a blanket of stationary coal, the rotor, of swing hammer type, revolving on ball bearings in the chamber with clearance all around. This acts as a closed end fan, drawing in all air required for combustion and sweeping it around with the coal in suspension, discharging it into the separating chamber.

The Riley Atritor in a full size model set up for actual operation was displayed by Riley Stoker Corp. This was opened to show the feeder and separator construction and the two effects in the pulverizing chamber. In the first effect hammers are used for the preliminary pulverizing and in the second effect a wheel carries pegs which rotate between stationary pegs. Fineness of pulverization is not dependent upon small clearance between these pegs but upon other factors. The machine has low power consumption and ability to sustain fineness of the material even allowing for wear on the pegs.

A standard type of Harrington traveling grate stoker was exhibited showing the interlocking of grate bars and the non-sifting features which allow this stoker to burn both bituminous and anthracite coals. This stoker was arranged for operation and was equipped with an Indiana coal spreader. This spreader consists of a traveling chain driven from a small motor attached to the stoker frame,

and a link, one end of which slides in a roller on the chain, the other being attached to the free end of the coal spout.

A self-contained traveling grate stoker was described by Combustion Engineering Corp. in a bulletin distributed at its booth. This combines in one unit, movable in and out of the furnace on a track, a stoker unit combining a traveling grate, forced draft fans, coal hopper, reduction gear, change speed gear and electric motor for driving fans and stoker. This unit is designed for use with all types of coal and can be adapted to existing natural draft installations with little change in the existing boiler setting.

Burke Engineering Co. had a comprehensive exhibit of its traveling grate stoker, its fuel-saving, smoke-preventing furnace and the U. S. rocking grate. On the traveling grate stoker attention was called to the drive sprockets with roller contact, the details of the grate bars showing ease of replacement, the solid rear end construction and the fact that the grate surface was not a part of the drive mechanism or endless chains.

Designed for small heating boilers and hot water heaters, the Iron Fireman automatic coal burner, displayed by the Iron Fireman Mfg. Co., attracted attention. Coal, shoveled into a hopper in this small stoker, is carried forward by a worm to a retort placed in the fire box, gases rising through the fuel bed being supplied with air from a small blower.

ATTRACTIVE EXHIBITS OF VALVES, FITTINGS AND INTERESTING DISPLAYS OF PIPE JOINTS AND PIPE WELDING

A—Walworth Co. showed a Walworth Sigma Steel gate valve equipped for motor operation. B—Cut-out models of gate and globe valves were featured by The Lunkenheimer Co. C—The toggle-top stop check valve, shown by Schutte & Koerting Co., attracted attention, as did the Radiafin oil and air coolers. D—Pittsburgh Piping & Equipment Co. showed a model of its pipe construction and a new type of welded header and nozzle. E—The Midwest ball and socket pipe joint was shown by Midwest Piping & Supply Co. F—Illinois Engineering Co. featured the new Eclipse 35 bucket trap.

Boilers, Superheaters and Economizers

The new Combustion Steam Generator was exhibited by Combustion Engineering Corp. by the use of a Scene-In-Action illuminated sketch. This generator is essentially a furnace, the walls of which are constructed of fin tubes connected by suitable headers to drums and provided with a small number of outside circulating tubes. The illuminated sketch showed how the radiant heat from the flames of pulverized coal burners placed in the corners of the furnace impinges directly on the walls, in which the water circulates, steam being forced to the steam drum where it is removed. Entrance of secondary combustion air was shown, as well as the passage of flue gas down to

the bottom of the furnace and then through a superheater and an air preheater before going to the induced draft fan and stack. Ash drops through a water screen at the bottom of the combustion space.

The Walsh & Weidner Boiler Co. displayed two seamless forged steel section boiler headers for a 400-lb. boiler. Each header section is one tube wide and the ends of the headers are closed by being dove-tailed into square plates and then welded. They are made of heavy seamless steel tubing. Interesting photographs of the largest hydraulic riveter with a forged steel stake now in use were shown.

Heine Boiler Co. exhibited a new type of seamless forged steel, drop leg, sectional header, forged by a special process and having the ends closed so that the metal is upset to give increased bearing surface for the connecting nipples. Sides are slightly hollowed to retain the packing seal when the headers are nested. Interesting diagrams were exhibited showing the quality of the steam and variation in water level in the Heine bent tube boiler.

Freeman Manufacturing Co. showed by drawings and photographs details of its fire tube and water tube boilers. The latter are made in longitudinal and cross drum types of the water leg type, wide tube spacing being provided and the hand holes and tube holes in the water leg being drilled out of solid plate.

Casey-Hedges cross-drum and longitudinal drum water tube boilers were shown by drawings and photographs at the booth of The Casey-Hedges Co. Forged steel nozzles, header construction and forged steel hand hole plate construction were noted.

In the Nuway boiler, exhibited by the Nuway Boiler & Engineering Co., provision is made in a fire tube boiler to increase the circulation by grouping the tubes in nests with spacing between the nests. End baffle plates and return guide plates are provided to guide the circulation and the tubes in the individual nests have an open staggered arrangement. The result is an increased evaporating capacity, better quality of steam and lessening of foaming and priming, closer steam pressure regulating position and more efficient heat absorption by the boiler.

Power Specialty Co. demonstrated the forged steam elements of its radiant type superheater and displayed by drawings and photographs the construction of the Foster convection type superheater and the Foster economizer, built as integral parts of the boiler structure.

In addition to units taken from Elesco superheaters now being built for the Des Moines Station, The Superheater Co. had an interesting exhibit showing the steps in the manufacture of the ball joint and header section. Another display showed the method of joining two lengths of tubing into a continuous return bend by forging, thus giving great flexibility and simplicity of construction.

B. F. Sturtevant Co. showed its new lead-coated Economizer and plate type Air Economizer. The tubes of the lead-coated Economizer are provided with discs to increase the heating surface, a section of tube showing the way in which the tight joint is made between disc and tube. A soot blower is provided for cleaning in each section of tubes. The chambers of the air economizer are of the welded plate type in separate units made reversible, so that when corrosion at the cold end has reached a certain point, the chamber can be turned around, thus lengthening its life.

Working models of the Carrick combustion control equipment were shown in full size by Carrick Engineering Co. In this system the master controller is actuated by a mercury column from steam pressure and the auxiliary control multiplies the power of the master or changes the relation of one unit to another. The furnace regulator is operated from furnace pressure and can be made to control forced draft, powdered coal feed, or some part of the furnace from the furnace pressure.

Bailey Meter Co. featured the recently announced Bailey meter control for automatic boiler operation. Panels bearing this control were set up and the equipment was shown in operation. In this system the rate of supply of both fuel and air to the various boilers is changed in accordance with the demand for steam. At the same time the equipment regulates the ratio of fuel and air supplied to each boiler, so that the proper amount of excess air is present to fit the given operating conditions.

The Hagan system of combustion control was shown by Hagan Corp. The primary control is by the load on the plant and individual boilers are controlled to suit the varying fuel bed conditions.

Soot Blowers

Details of construction of several types of soot blowers were shown in the exhibit of The Bayer Co. The Bayer balanced valve in head, two types of geared heads and the direct drive head were shown; these may be used with the non-warpable, air-cooled element. This element is built in sections divided by expansion sleeves which take up the movements that cause warping. The inner element is protected by an outer sleeve with an air space between, thus permitting air circulation.

New Dialoy soot blower elements for unusually hot locations were shown by The Diamond Power Specialty Corp., several pieces of the Dialoy being shown after use in temperatures up to 2000 deg. A complete working model of an electrically operated automatic soot blowing system was exhibited, using 3 motor driven heads. Operation of the main line valve and the heads by the master controller was shown and the 3 motor driven heads were actuated in any predetermined manner by remote control.

The new Vulcan self-contained valve operating soot blower head, shown by The Vulcan Soot Cleaner Co., has a valve which is integral with the head; this valve is a swing disc, self-grinding and positive in action and is operated by one handle or chain which moves the rotable element. All parts are easily accessible, the element can be rotated 345 deg. with the valve fully opened, there is no stuffing box or sliding stem and the valve does not depend on a spring for final closing. The rotary part is carried on ball bearings. A sheathed element can be furnished for high temperatures, as well as the Crodon heat resisting element for temperatures up to 2200 deg. F. There was also featured the new Vulcan ratchet operating head, which gives step-by-step rotation of the element.

Furnace Construction

Another item of interest was the display of photographs and drawings showing the new Bailey water-cooled front and rear arch for chain grate stokers, as they are being installed in one plant at the present time. A typical section of this wall for pulverized fuel furnaces was exhibited showing how the refractory faced cast iron blocks are clamped to the water tubes and how an inspection door can be installed. A full size Bailey pulverized coal feeder and meter, designed to feed 10,000 lb. of coal an hour at the uniform rate, was demonstrated.

The fintube furnace wall was shown by Combustion

Engineering Corp. by typical sections of the full size wall. One of these showed a new method of installing; specially shaped brick refractory blocks are placed behind the fins and the space behind and around these blocks is filled with mineral wool or other insulation of that character. The blocks are about 2 in. thick and the insulation about 2½ in. thick. It is possible to remove individual tubes without withdrawing support from any part of the wall.

The nose tile in this arch is replaced without disturbing adjoining tile. Emphasis was placed on the adaptability of the National stoker for burning wood refuse and bagasse.

Liptak Fire-Brick Arch Co. had an exhibit of its type G air-cooled, side wall construction especially adapted for the boilers of large plants, showing the wedge brick and interlocking units. The support of walls by vertical

BOILERS, CONTROL SYSTEMS, FURNACES AND VARIOUS PLANT ACCESSORIES WERE CENTERS OF INTEREST

A—Adsco guided type expansion joints and underground steam lines were of interest at the booth of American District Steam Co. B—The Nuway Boiler & Engineering Co. demonstrated by a model the circulation in its horizontal return tubular boiler. C—Furnaces may be inspected during operation through the observer shown by Vastine Sales Corp. D—A 130-lb. arch held by half of an Adamant joint aroused interest at Botfield Refractories Co.'s booth. E—Connery & Co., Inc., showed a section of breeching with the Improved Expansion Stiffener. F—Bailey Meter Control in full working operation was demonstrated by Bailey Meter Co. G—An illuminated drawing of the Combustion Steam Generator and types of fin-tube furnace wall construction were shown by Combustion Engineering Corp.

The M. A. Hofft Co. showed its National hand operated stoker combined with the National flat suspended arch in an actual setting for a 150-hp. boiler. Each tile in the arch is carried on a separate hook for easy replacement. A small motion picture machine showed how an old block is cut out and a new one put on the hanger and replaced without disturbing the others.

buckstays and by castings kept well away from the heat zone was also illustrated. Liptak double suspension arches were exhibited, showing how the upper blocks protect the supporting structure of steel I-beams and castings and the lower blocks supported on the upper ones served as the furnace arch.

Plibrico Jointless Firebrick Co. showed a slab of Pli-

brico taken from a test furnace after having been used at temperatures up to 3050 deg. F., together with a section of firebrick wall that had been subjected to the same temperature.

Vastine furnace fire observers were exhibited, as installed in boiler walls, by Vastine Sales Corp. The device is designed to permit observation of fire and brick work at all times without letting cold air into the furnace or allowing heat to escape. It has an air-cooled casing with a glass front and can be supplied for natural air circulation or for forced circulation of air through the casing by a blower.

Quigley Furnace Specialties Co., in an attractive display showing the installation of Hytempite, called attention to its burner blocks for use with various types of coal and oil burners. These blocks can be made up of a mixture of old fire brick and Hytempite using about 25 per cent Hytempite to 75 per cent crushed fire brick.

Harbison-Walker Refractories Co. featured its recently developed block for air-cooled furnaces, attention being called to the care taken in making and burning this block to prevent warping, undue shrinkage and cracking.

M. H. Detrick Co. displayed wooden models of its Detrick flat suspended arch showing the details of the end construction. A model using wood blocks to represent tile showed the Detrick sectional supported side wall construction for pulverized fuel and other high temperature furnaces.

The Drake improved interlocking-face blocks, made by Drake Non-Clinkering Furnace Block Co., were exhibited. These showed how the body section of the block is made of fire clay and the interlocking sections of carbo-glaze.

EQUIPMENT FOR HANDLING COAL, AIR, WATER AND OIL WAS SHOWN IN PROFUSION

A—Coal crushers, meters, pumps and valves were displayed by Ernest E. Lee Co. B—The De Laval Separator Co. featured a purifier for preventing aeration of transformer oil during purification. C—Turbines, air and water heaters, regulators and valves filled the booth of D. H. Skeen & Co. D—Armorframe crushers and Bradford Breakers were shown by Pennsylvania Crusher Co. E—Quigley Furnace Specialties Co. had an attractive boiler room scene to illustrate the use of Hytempite. F—A model of the Timken steel mill and specimens of Timken roller bearings were attractively shown by The Timken Roller Bearing Co.

In the booth of the Norton Co. was shown a section of the Riley lateral retort stoker with a setting of Norton refractories, using Crystolon bricks at the clinker line and bridge wall, set in Norton refractory cement. A special feature of the exhibit was the Waite & Davey air cooled furnace block made of Crystolon in a special patented shape, with an interlocking bell and spigot joint.

Of particular interest at the booth of Botfield Refractories Co. was a specimen of part of an air set arch using Adamant high temperature fire brick cement. This arch was made of two courses of 9 brick each, having a total weight of about 130 lb., the outer end having no support at all and the entire weight of the arch being taken by the fire brick joint at the inner end.

Warren Webster & Co. showed in an attractively arranged working exhibit its entire line of Webster type R modulation system of steam heating for various purposes. A small boiler was installed with radiators showing the position of the modulation valves and return traps, Webster sylphon packless valves and the damper regulator.

At the booth of the Buffalo Forge Co. a feature of the exhibit was a 96-in. Type K, disc fan with a rated capacity of 75,000 cu. ft. per min. which was driven very slowly by the air blast from a 135 cu. ft. per min. blower driven by a 1/10 hp. motor. The large fan was fitted with Dodge Mfg. Co. pillow, block and Timken bearings.

In the Duplex Conoidal fan attention was called to the rugged mechanical construction, the water-cooled bearings, outside construction away from the hot gases and the thrust collars turned on the fan shaft.

In addition to its Type FD fan, previously described in these columns, Clarage Fan Co. exhibited a Type V, 4-in. by 4-in. enclosed self-oiling vertical steam engine for small generator drives, air compressors, fans, line shafting and the like. This is furnished both with fixed eccentric and fly-ball throttling governor and with Rites inertia governor.

B. F. Sturtevant Co. showed the cinder-vane fan for removing dirt from flue gas. This consists of a straight blade paddle wheel fan, each blade of which has three V-shaped compartments on the back of it. Dirt catches in these compartments and the centrifugal force throws it out at the side into compartments in the casing.

Connery & Co. Inc. displayed a section of its boiler breeching 6 ft. wide, 15 ft. high, 25 ft. long, with two uptake connections calling special attention to the improved expansion stiffener and the electrically welded construction of the breeching throughout. The expansion stiffener allows rigid construction and at the same time provides for expansion. An asbestos packed cleanout door, an improved air-cooled damper and other details were shown.

Ernst & Co. called attention to its "C-Red" gage glass color injectors for injecting "C-Red" liquid into gage glasses. The injector is operated from the floor level, the liquid being allowed to displace only the water in the glass. It may be installed on inclined or vertical gages. There was also shown an Ernst inclined gage glass for high pressures and temperatures.

At the booth of Wright-Austin Co. attention was centered on an extra heavy water gage for steam boilers. This was equipped with the new Crescent weighted try cock for 400 lb. pressure service, the monel metal whistle valve and the usual float and valve construction.

HEATERS, FILTERS AND COOLERS FOR AIR, WATER AND OIL

An operating model of the Ljungstrom air pre-heater showed the rotating element of sheet steel carrying heat from flue gas to air, the propellor type fans for cold air and cooled flue gas, the electric welded construction, the soot blower for cleaning the rotor and other interesting features.

An interesting type of air filter was shown by the National Air Filter Co. at the booth of Foster-Bolton Co. In this filter air passes through a cylinder of copper gauze which rotates under normal conditions about once in 16 hr. An oil spray is placed inside the cylinder and the rotation presents new oil surfaces to the incoming air as needed. Oil seeping through the copper gauze drains into a pan at the bottom, where it is cleaned by settling and filtering.

A feature of the new Featherweight unit heater manufactured by L. J. Wing Mfg. Co. is that the heating element is made of copper, thus lessening the total weight of the heater. This allows it to be hung on the ceiling or on columns, instead of setting it on the floor.

At the booth of Marion Machine Foundry & Supply Co. attention was called to a sectional model of the Marion Gulf Stream water heater. Water entering the specially constructed water chamber passes through in the form of a thin cylinder with steam on the inside and steam on the outside. The heater is made in various sizes for various steam pressures from 1 to 25 lb. One type of heater using 5 lb. steam pressure is designed to produce a temperature rise of 100 deg. F. in 900 gal. an hour.

The Andale oil cooler, also exhibited by Wolff & Co., has for its principal features the permanent connections to the shell of the cooler made in such a way that it is not necessary to break any pipe joints in order to remove the tube bundle for cleaning. All openings in the shell through which liquid flows are bored, thus insuring a smooth surface. The tube bundles are held by forged bronze tube sheets, the tube being expanded into sheets by a special groove arrangement which allows hard expansion.

A portable type oil purifier for transformer oil, known as the Conservator type, was shown by The De Laval Separator Co. This is designed to prevent aeration of the oil while it is being purified. A special construction of an overhead reservoir above the regular bowl is necessary to prevent air from entering.

An interesting type of dry feeder for proportioning chemicals in a water treatment plant was shown by Power Plant Specialty Co. A proportioner meter is used, the reciprocating motion of the pistons being changed by a link motion to rotating motion. This rotating motion actuates a bronze screw conveyor in the bottom of a hopper, which feeds this conveyor with chemicals.

At the booth of Andrews-Bradshaw Co. a complete full size working model of the Tracyfier was in operation to show the removal of fog, mist and other forms of boiler water from steam. Attention was called to the fact that the water taken out of steam by this purifier is not distilled water. This was demonstrated by a simple test, in which water containing impurities was boiled in chemical equipment and the foaming action in a boiler was demonstrated.

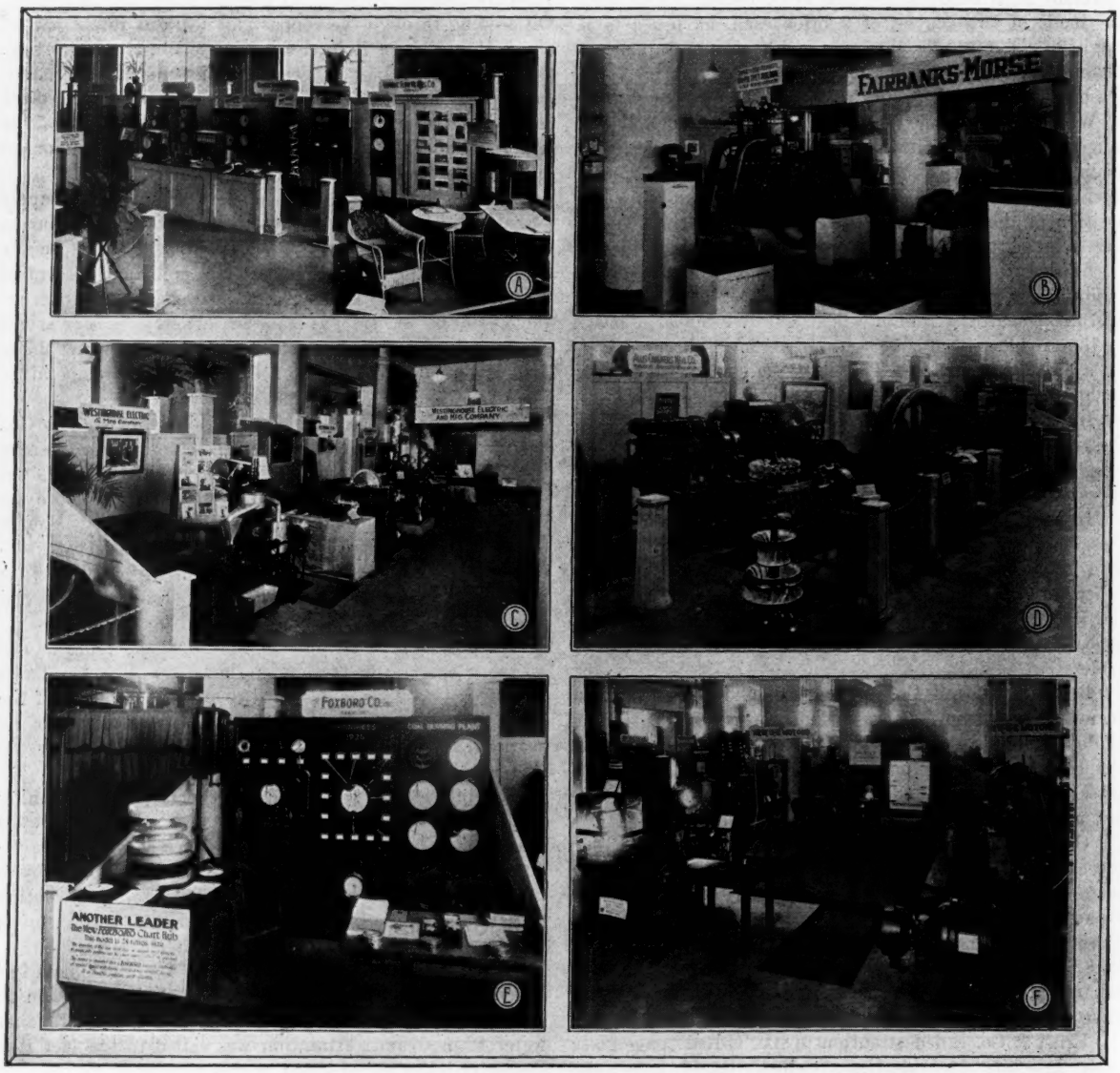
Centrifugal separators for a variety of services were featured by Centrifix Corp. One model shown was of the full automatic type used in industrial evaporators to remove the entrainment that may pass out with the vapors. For steam boilers a single unit of the full automatic type recently developed, discharges the separated water into the drum, eliminating outside piping.

The Hagan steam purifier was shown in operation, handling air and water to show operation similar to that in a boiler. This purifier is installed instead of a dry

pipe in the boiler. In the model exhibited, water was sprayed into the top of the purifier, air being drawn through by an induced draft fan. A glass insert in the air pipe going from the sprayer to the fan showed how the moisture had been removed in the purifier. The most recent development of the Hagan Corp. is a method for removing a small quantity of the boiler water during operation, filtering it and returning it to the boiler.

thrust, thus eliminating the need for balancing pistons or special thrust bearings. These pumps are built with from two to 12 stages by Manistee Iron Works Co.

Two Bethlehem boiler feed pumps of the Weir type were shown by Bethlehem Shipbuilding Corp., Ltd. One of these was a 900 g.p.m. single stage, turbine driven pump for operation against a 700 lb. head, similar to those installed at Crawford Avenue. The feature of this unit is



EXHIBITS OF SMALL TURBINES, MANY IMPROVEMENTS IN MOTOR DESIGN AND NEW TYPES OF RECORDING AND INDICATING INSTRUMENTS

A—Draft indicators, coal meter and flow meters were featured by Republic Flow Meters Co. B—Fairbanks, Morse & Co. exhibited the type Y solid injection Diesel and an assortment of ball-bearing motors. C—Sharples Super-Centrifuge, Auto-valve arrester, mechanical drive turbines, motor bearing improvements at Westinghouse Electric & Mfg. Co.'s booth. D—Allis-Chalmers Co. emphasized the Reyrolle armorclad switch gear, water turbine runner models and the Texrope drive. E—The Foxboro Co., Inc., showed its new chart hub and recording and indicating meters of all types. F—The new General Electric Co. household refrigerator, the mechanical drive turbine and improved G. E. motors formed a focus of interest.

Pumps for Boiler Feed, Oil and Other Services

A Manistee Roturbo 4-stage boiler feed pump was displayed, designed to pump against a head of 600 feet. This was opened to show the double suction and impeller design, the rotor being hydraulically balanced to prevent lateral

that this extremely high discharge pressure is obtained in a pump with only one stage. The impeller is of the single suction shrouded type, the pump casing and impeller being made of bronze. The shaft is of chrome nickel steel.

A full size model of a Bethlehem self-contained oil

pump and heating unit as furnished for the Bethlehem-Dahl oil burning system was also shown. This unit consists of Bethlehem-Weir fuel oil service pumps in duplicate, oil heaters in duplicate, suction and discharge strainers in duplicate with necessary piping, gages and fittings—all mounted on a welded steel base.

In an attractively arranged booth, Nash Engineering Co. displayed various types of the Jennings Hytor vacuum and condensate pumps and the Hytor sewage ejector. A colored drawing of the Hytor condensate pump showed the construction of the rotor and also demonstrated how the water alternately recedes from and re-enters the rotor and how, on passing out into the casing, it draws air through the inlet port, thus creating a vacuum.

Yeomans Brothers Co. exhibit contained the Shone type SDV Duplex Pneumatic Sewage Ejector, complete assembly in actual operation showing purely mechanical principle of the machine as operated from general air supply. Type V.S.F. vertical centrifugal Sewage Pump for handling crude sewage, effluent or sludge in municipal service was also shown. This type of pump is frequently equipped with special non-clogging impeller capable of handling solids almost as large as the discharge orifice. A type H.C.C. Condensation Return Pump was shown with cast iron receiver and enclosed automatic control, all mounted on continuous base, suitable for returning condensate to boilers in gravity return heating systems.

Steam Turbines and Engines

The General Electric mechanical drive steam turbine attracted much attention. This unit is horizontally split with all steam connections in the bottom of the casing. The emergency governor is separate from the main governor and an oil pump supplies oil to the main governor and also to the bearings.

Several types of small Westinghouse mechanical drive turbines were on display. One was a 7½ kw. direct connected d.c. unit, another a type MD unit for auxiliary drives, with water sealed glands, single wheel and reversing chamber and a third a single wheel 35 kw. d.c. unit driving through a Westinghouse herringbone reduction gear.

The Moore steam turbine for mechanical drive was shown, direct connected to a Moore guided inlet, 2-stage double suction centrifugal boiler feed pump, a Moore flexible coupling being used. The turbine which was a 3-velocity-stage, impulse type, 350 hp. unit. Wearing parts of the governor are made of tool steel, hand control of nozzles is provided and the governor pivot is not rigidly connected to the governor spindle.

Allis-Chalmers Mfg. Co. exhibited several interesting models of water wheels, attractively mounted on a display spindle. These included the typical impulse type wheels, propeller runners for low heads and Francis type wheels. A small velocity stage impulse turbine for auxiliary drives was exhibited. Allis-Chalmers Mfg. Co., also had the second commercial Parsons steam turbo-generator ever built.

Another small turbine for mechanical drive of auxiliaries that attracted attention was the Kerr turbine, displayed by Elliott Co. In this turbine large bearings are used far enough out from the casing to insure coolness. The governor weights revolve in a cage on the end of the shaft in such a way that the governor spindle does not revolve but simply moves in and out of bearing. This allows oil to be forced in through a hole in the spindle to lubricate all parts of the governor thoroughly.

At the booth of B. F. Sturtevant Co., special attention was called to an underfeed stoker fan unit consisting of the design 5 turbo-vane fan, driven by a B-12 auxiliary drive Sturtevant turbine. The feature of this turbine is the straight blade construction of the buckets requiring a special machine and special processes in manufacturing. It is stated, however, that this construction develops the full value of the strength of the metal.

Troy Engine & Machine Co. showed a type S-H vertical steam engine, calling attention to the short direct steam ports, partially balanced ground-in steam valve with expansion ring and flat spring to compensate for wear and other features. Main bearings are cast integral with the frame. An oil pump is submerged in an oil reservoir in the base; this pump receives oil from the strainer and pumps it through oil pipes and fittings to main bearings, cross head, valve drive rod and crank pin, all oil fittings being permanent.

Condenser Equipment

Photographs of new types of Wheeler single pass and two-pass condensers were shown by Wheeler Condenser and Engineering Co. A small working model of the Wheeler cooling tower showed the enclosed sides and the application of the counter current principle.

Schutte & Koerting Co. exhibited a large multi-jet condenser and an ejector condenser showing how the vacuum is kept within ¾ in. of the barometer without the use of air pumps. A special feature of the exhibit was the Radiafin generator air cooler. Sections of the tubes of this cooler showed the oval construction to give stream line flow of water and the fins on the outside of the tubes.

Of special interest at the booth of C. H. Wheeler Mfg. Co. were photographs of the 70,000-sq. ft. condenser at the Richmond station. The aim in this design is to get the condensate temperature as near as possible to that of the exhaust steam by providing the least possible pneumatic resistance between the exhaust inlet and the air pump suction. This is done by making the condenser of dual-bank type with an open space between the two banks.

An interesting photograph was also shown of the 54 in. circulating pump for this condenser, designed to handle 85,000 gal. per min. A 5000-kw. type-TCA Radojet air pump was exhibited. This unit was to be shipped to one of the power plants of the Viscose Co.

Valves for Steam Water and Oil

Walworth Co. exhibited a complete line of its new Sigma steel fittings and valves. A 12-in. gate valve of this material for 400 lb. pressure was shown equipped with Dean control. In this valve the hubs carrying the seat rings project into the spherical part of the body, insuring uniform temperature of rings and supporting metal. In addition, all surfaces of the valve are spherical or cylindrical. A sectioned casting for a valve was displayed to show the shrinkage of the metal and the way in which the Walworth design makes provision for this shrinkage.

In the manufacture of hydraulic presses, The Hydraulic Press Manufacturing Co. found it necessary some time ago to develop its own types of drop forged steel fittings. One group of these valves and fittings was shown that were designed for a hydraulic pressure of 10,000 lb. per sq. in.

Dean valve control was featured by the Cutler Hammer Mfg. Co.; Dean power units were mounted on an 8-in. Schulte & Koerting gate valve and on a 6-in. Edward gate valve. Emergency stations for closing valve only were shown in both wall and switchboard models. Control stations for opening or closing, or both, were interlocked so that when the valve was operated from one control station, the others were locked out. A special feature was the new Dean control unit for 3-in. valves used in high pressure oil lines in refinery work. Attention was also called to the new tubular heater element. An electrical heating element is run through a tube of compound and the whole may be used as an immersion heater for water heating, in which case a copper tube is used, or as a heater element cast in the top of a stove, in which case steel or monel tubes are used.

The feature of the piping exhibit of Midwest Piping & Supply Co. was a 10-ft. section of pipe set up with Midwest joints to show the deflection of approximately 5 deg. that may be taken up by these joints. This pipe section was kept under a hydraulic pressure of 1500 lb. per sq. in. The feature of the joint is the ground ball and socket arrangement which eliminates gaskets. The joint is not welded.

Wm. A. Pope described high pressure piping installations, featuring the Sargol joint developed in conjunction with Sargent & Lundy, Inc.

A motor-operated steel gate valve for 400 lb. pressure

MANY INTERESTING TYPES OF PUMPS, METERS AND REGULATORS HELD THE ATTENTION OF VISITING ENGINEERS

A—Radojet air pumps and photographs of large condensers were of interest at C. H. Wheeler Mfg. Co.'s booth. B—Bethlehem Steel Corp. showed the new pulverizing mill and Bethlehem Shipbuilding Corp. displayed fuel oil and water pumping equipment. C—A most attractive exhibit of Jennings Hytor condensation pumps and sewage ejectors was made by Nash Engineering Co. D—Yeomans Bros. Co. showed the Shone Sewage ejector, and vertical and horizontal centrifugal pumps. E—A variety of regulators, traps, and temperature control apparatus was exhibited by The Powers Regulator Co. F—The Simplex Valve and Meter Co. had a working model of a Venturi tube boiler feed meter.

was shown by The Wm. Powell Co. When desired a radial adjustable pad can be supplied on these valves to hold the control motor in any position around the valve. These valves are furnished for pressures up to 900 lb. White Star valves with removable seat and disc were shown for 200 and 300 lb. pressure. Bronze valves for pressures up to 2000 lb. were shown in gate, globe and check types.

Edward forged steel valves for pressures up to 500 lb. and intermittent temperatures up to 1100 deg. were shown in sectioned models. These valves are made by Edward Valve & Mfg. Co. in the globe and angle types with either plug type stem and integral disc or protected seat and disc. The design provides for straightaway flow, and removable seat; body, bonnet, gland and union units are of solid steel forgings and other parts of monel metal.

A complete display of several types of chrome nickel steel fittings and valves for 400-lb. pressure service was made by Chapman Valve Manufacturing Co. A 16-in. chrome nickel steel gate valve for 400 lb. pressure and 1000 deg. total temperature was set up for operation by means of the Chapman valve control. This valve control was designed for ruggedness and simplicity by the Chapman Company using standard General Electric Co. parts. Special attention was called to the spindle joined to the gate and disk by a pin and a Woodruff key, allowing the spindle to be easily removed without taking the valve from the line.

Type B hollow piston blowoff valve of Yarnall-Waring Co. was exhibited as arranged for high pressures with planetary gears and a crank on the hand wheel for easy opening and closing.

American District Steam Co. called attention to its duplex sleeve guided type expansion joint for high pressure and superheated steam service. In this joint an inner and outer slip are welded together at one end with the outside surface of the other slip riding against the packing. Space between outer and inner slips is cooled by air circulation.

At the booth of Ric-wiL Co. the feature of the exhibit was a miniature steam distribution system to show the Ric-wiL underground construction and especially the new Loc-liP joint. This is a longitudinal joint, made with a fitted lip and groove. In installing this conduit the joint is filled with the usual type of cement used for this work.

Jenkins Bros. exhibited a complete set-up of glass tubing and Jenkins Bros. valves, the latter having glass plates set in the bodies so that the flow through them could be observed. Water was pumped through the piping and valves and the conditions of flow at each point in the circuit were easily seen. A valve for 225 lb. pressure, using a composition asbestos disc and a solid union bonnet was featured.

Pittsburgh Piping & Equipment Co. featured the American Patented Welded Neck for high pressure headers. The feature of this neck is that a band which is an integral part and an extension of the nozzle piping surrounds the main header to which the nozzle is welded,

Dexter valve reseating machines, made by Leavitt Machine Co., were shown in various types and sizes for reseating both globe and gate valves. The machine is clamped to the body of a globe valve and centered by rotating the scroll of the chuck. In the case of a gate valve, a different type machine is needed, the cutter support being quickly attached and centered and a few rotations of the cutter sufficing to reface the seat.

The reverse current valve made by Atwood & Morrill, especially developed for the bleeder lines from turbines to bleed heaters, to prevent water from the heater from backing up to the turbine, was also shown. This has a Duralumin poppet valve with a dashpot and is designed to give full opening and minimum pressure drop.

The exhibit of Everlasting Valve Co., through its western representatives, The Scully Steel & Iron Co., featured the tandem model X blowoff valve embodying two valves with various types of control.

The Lunkenheimer Co. had an interesting exhibit of small valves made entirely of monel metal for 400-lb. and 750-deg. work, similar to those installed at Richmond station. A 10-in. gate valve for 400 lb. and 750 deg. was shown with motor drive and a cutout model of a 6-in. motor operated valve with Sargol joints for 900 lb. pressure. A 6-in., 900-lb. rough valve body just out of the mold was displayed to show the quality of the casting.

Steam Traps

Powers Regulator Co. displayed, in addition to its standard line of regulators, the Powers high pressure steam trap which, in the ½-in. size, discharges 1500 lb. of condensate per hr., at 100 lb. pressure. This is a thermostatic trap, the valve being actuated by the movement of expansible monel discs.

Sarco Co., Inc., featured its new No. 9 self-adjusting trap. The No. 9-4, the latest development of this trap, uses the balanced pressure principle in multiple form. The seat is below the valve, opening to give quick flush action. The Type TR-35 temperature regulator was also exhibited. This is of the self-contained type and utilizes the expansion and contraction of the sensitive liquid hermetically sealed in the apparatus. Temperature regulators are now supplied in 10, 12 and 14-in. sizes and with standard range and long range of 100 deg. F.

The Eclipse steam trap was featured by Illinois Engineering Co. This is a newly developed bucket type trap, in which the valve is driven opened and closed by the impacts of the falling or rising bucket, instead of using the slow pull of a dead weight bucket. This result is secured by having the valve or valve stem free from direct or rigid attachment to the bucket. As the bucket sinks when the trap is falling, the valve stays closed until a shoulder on the bucket guide strikes a shoulder on the valve stem and opens the valve. The reverse action takes place when the trap is emptying. The Eclipse improved trap is supplied for operation at pressures up to 350 lb.

Coal and Ash Handling Machinery

The Hydro-jet system of ash removal, in which high pressure jets of water force the ash from cast iron ash hoppers down into a sluiceway, was featured by Allen-Sherman-Hoff Co. Ash is carried through the sluiceway by other high pressure water jets, operated intermittently from the boiler room floor or from any convenient point.

At the booth of R. H. Beaumont Co. an interesting model of a complete coal handling system was shown in operation. This was driven by a full sized winding machine, although the total capacity of the model was only about 100 lb. per hour. Coal was distributed in the coal storage area by a tiny drag scraper and was loaded into a skip hoist, having a capacity of about 1 lb.

Pennsylvania Crusher Co. gave an interesting demonstration of its new Armorframe, single roll crusher, show-

ing in particular the action of the shear pin which shears and stops the crusher in case tramp metal, wood or other obstructions enter the crusher. This prevents the breaking of the frame that might otherwise occur. The Armorframe has capacities up to 300 t. an hr., but is more largely used by plants requiring 5 to 100 t. an hr. The Bradford breaker, a model of which was also shown, has capacities up to 500 t. an hr.

An American ring coal crusher, made by the American Pulverizer Co., was exhibited by Ernest E. Lee Co. The rings are suspended on 2-in. shafts and can be thrown back 4 in. thus making the crusher self protecting against foreign material. It is adapted to crushing run-of-mine coal to ¾ in. and the No. 60 crusher is designed for a capacity of 350 t. an hour.

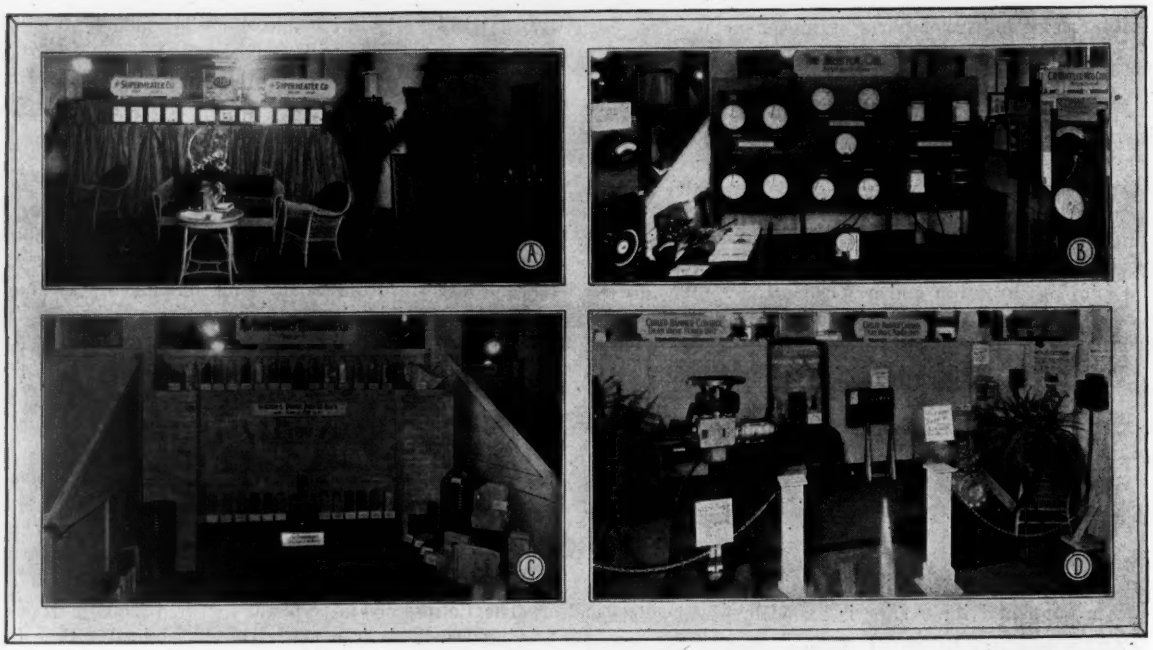
Mitchell vibrating screens, made by C. W. Hunt Co., Inc., were demonstrated in a working model by Phillips Lang & Co. The screen is vibrated 60 times a second, the screen cloth having a motion up into the material to be screened and at the same time a side sifting motion. The surface of the screen is 15 sq. ft., and the vibrators are driven by three-phase 50 or 60-cycle a.c. at 220, 440 or 550 volts.

Sauerman Bros. exhibited an interesting miniature model of its drag scraper handling coal in a storage pile. The scraper is of curved plate design to eliminate stresses and reduce the weight.

Electrical Equipment

The new General Electric Co. household refrigerator was of particular interest. This refrigerator using SO_2 as a refrigerant is a self-contained, totally enclosed unit, requiring only to be plugged into a light socket. A vertical motor is used driving from an eccentric a compressor which has two oscillating plungers. The power plant and condenser are entirely independent of the box; no moving parts are exposed and since the lubricating oil is mixed with the refrigerant no attention is required for this during operation. The condenser is air-cooled and the machine is practically noiseless. The unit exhibited was the largest type now being manufactured, installed in a Seger refrigerator. By early summer it is expected that a smaller size model at a lower price, suitable for apartment use, will be on the market.

Cutler-Hammer Manufacturing Co. called attention to its new "Across-the-line" automatic starter for alternating current motors from ¼ to 30 hp. and are totally enclosed with overload and low voltage protection.



METERS, REFRACTORIES AND VALVES WERE SHOWN

A—Sections of a superheater and steps in its manufacture were demonstrated by The Superheater Co. B—The Bristol Co. showed indicating and recording gages for all services. C—Harbison-Walker Refractories Co. displayed its products attractively. D—Cutler-Hammer Co. had Dean valve control units, the across-the-line starter and a new heater element.

In the various electrical exhibits that of the Reyrolle Armorclad Switchgear, featured by Allis-Chalmers Mfg. Co. attracted a great deal of interest. This is a new type of switchgear designed to bring together in one small unit the disconnecting switches, bus bars, potential and current transformers, oil circuit breakers and relays. The unit as installed at the Allis-Chalmers booth was a 3 phase, alternating current unit. Disconnection is provided by withdrawal in a horizontal direction of the carriage type oil circuit breaker, automatic locking of doors being provided to close the orifices of the disconnecting switch circuit. The operation of the panel is protected by positive mechanical interlocks. The fixed portion of the panel incorporates the bus bars, instrument transformers, cable dividing boxes and supporting framework. The removable portion includes the emergency type oil circuit breaker with the necessary operating mechanism.

The design provides for safety by keeping all live conductors enclosed and inaccessible, except purposely, and the interlocking system reduces to a minimum the possibility of error. Coverings are such as to prevent the throwing out of flame or hot gases or the escape of gases in any

quantities from the equipment. It is suitable for voltages up to 33,000 and is at present furnished in ampere ratings up to 3000 amp.

A working model was shown of a 1½-in. single stage ball-bearing centrifugal pump, driven by a 7½-hp. ball-bearing motor at 3600 r.p.m., the whole unit made by Fairbanks, Morse & Co. Various types of the Fairbanks Morse ball-bearing motor were shown, one of the most interesting being an enclosed, self-ventilating ball-bearing unit, designed for grain elevators, flour mills and similar work to reduce chances of dust fires.

At the booth of the Cutter Electrical & Mfg. Co., I.T.E. circuit breakers and U-Re-Lite switches were shown. The I.T.E. (inverse time element) breaker shown mounted on a panel was a 4000-amp., 3-pole motor operated carbon circuit breaker for 550-v. service. A series wound d.c. motor operates this breaker through proper worm gear drive and its action is extremely rapid. The breaker can be thrown in by remote control, a special feature being the pressure exerted on the contacts. The U-Re-Lite switch is a small carbon circuit breaker in a box, designed for individual motor protection to replace fuses.

Among the developments in motor design, the new sealed sleeve bearing shown by Westinghouse Electric & Mfg. Co. was of interest. This bearing is designed to keep out the dust that causes excessive bearing wear and to keep the oil from working over into the motor windings and also from throwing and leaking out of the bearing. A shellacked felt gasket is put under the cast cover and the latter bolted down on it to prevent slopping out of oil at oil ring slot. An inner bearing cap stops leakage from careless filling and a by-pass for air prevents unbalanced air pressures in the bearing. Oil holes are closed by plugs; a felt washer and bearing cap lip seal the housing against air going out or in.

At the Westinghouse booth was also shown a working model of the Type LV Autovalve arrester. This showed how a surge blew through the arrester but when the arrester was taken out of the circuit, the surge flowed over one of the insulators.

Westinghouse Electric & Mfg. Co. displayed a working model of the Sharples Super Centrifuge, for which it now acts as distributor. This machine is a centrifugal oil purifier for reconditioning transformer, circuit breaker and turbine lubricating oils. A vertical rotating cylindrical bowl is used, the dirt passing to the outside and the clean oil passing to the center and rising to the top where it is drawn off. A complete line of Micarta products was also shown. Micarta is made by hot pressing sheets of fabric or paper which have been treated with an organic binder. The resulting material can be used for gears, can be drilled and machined and punched accurately and is not affected by ordinary solvents.

A new type of General Electric Co. brush-shifting motor was shown for variable speeds from 1650 to 550 r.p.m., the horsepower being 5 to 1.67, respectively. This wide speed range is obtained by a double set of shifting brushes, one set moving opposite to the other.

High speed wound rotor motors for direct connection were announced by General Electric Co. These are made in both two and three-phase, in sizes from 100 to 250 hp. for 440, 550 or 2200-v., 60-cycle service. They operate at 1200 or 1800 r.p.m. and may be obtained in constant or adjustable variable speed types. They are characterized by heavy shafts, oversize bearings and large capacity oil wells.

Feed Water, Pressure and Damper Regulators

Foster Engineering Co. exhibited its improved pressure reducing regulator. This unit has single bevel seated auxiliary and main valves, operated by one diaphragm, also an adjusting spring. Renewable seat rings are provided, together with ample port and valve capacities.

D. H. Skeen & Co. called attention to its Mercon constant reduced pressure regulator. This is an adaptation of the Mercon constant excess pressure regulator, except that in the case of the reduced pressure regulator the mercury column balances the desired reduced pressure by having the lower end of the mercury column connected to the under side of the regulator diaphragm.

The new type of twin generator for use on the S-C feed water regulator, to obtain greater sensiturity of operation, was displayed by S-C Regulator Mfg. Co.; this sensitive operation may be necessary with some types of high pressure boilers where the boiler drum is small compared to the steam demand. This regulation is made by using two of the regular generators in parallel; this arrangement moves the valve stem twice as far as one generator would for a given change in generator pressure.

The recently developed master control for pressure regulation and boiler room equipment to handle special conditions was displayed by S-C Regulator Mfg. Co. Two controls are used, connected in such a way that the action of one tends to oppose the action of the other, and the connection is taken off between them to type S control valves, which are placed at the points to be controlled.

A new type liquid level controller was shown by The Fisher Governor Co. in two models. In one model a pilot valve on the side of a float gage admits air or water pressure to the diaphragm of a Standard regulating valve. In the second type, known as the liquid transmitting model, the motion of the float is transmitted directly by a special liquid through a pipe to operate the regulating valve.

National Regulator Co. showed a section model of the A-Jacks high pressure regulator with compensator mounted on a board to show operation. This regulator operates from steam pressure, no water supply being needed. It applies graduated action to dampers, valves or rheostats and admits just enough steam pressure into the cylinder to pull the load.

The Copes feed water regulator was shown in operation on a large display board. Flashing signs called attention to the various movements of the regulator as the load on the boiler varied, this variation being indicated on a flow meter. By maintaining a continuous flow, and controlling the water level between fixed limits this display showed conditions as they actually exist in a boiler. An interesting feature was the movement indicator for remote indication of the opening and closing of the control valve, which is sometimes placed where it is not easily visible. The Copes feed water regulator is made by Northern Equipment Co.

Indicating and Recording Instruments

Republic instruments shown by Republic Flow Meters Co. included a new duplex draft indicator actuated by float control driving a disc through levers, similar to that used with the multiple indicator. This indicator was designed for indicating draft over and under the fire.

A new coal meter for traveling grate stokers was exhibited. In this meter, the grate speed and gate opening are mechanically measured and transmitted to the meter and since the width of the stoker is constant the meter can be calibrated to read cross-section times velocity or pounds per hour. A new duplex recording and indicating pyrometer was shown, and an electric steam flow meter. In the latter, which is of the orifice plate type, a varying mercury column makes electrical contacts in an electric circuit, which leads to the meter at any convenient point. A pyrometer with a point switch for measuring Diesel engine exhaust temperatures was shown.

Brown Instrument Co. had models of its instruments mounted and in actual operation. Flush type recording pressure gages and thermometers for panel mounting were shown. The electric CO_2 meter combined with indicating and recording pyrometers was in operation. The lead lined, water-cooled gas cell, automatic charging of batteries and balancing of cells in the recorder were demonstrated. A cutaway model of the latest type of recording thermometers showed the pen tension adjustment, pen arm, helix assembly, moisture-proof case and other features. This company also showed a Diesel engine exhaust pyrometer. The Brown liquid level gage shown at the New York Power Show was again featured.

A full size working model of the Simplex boiler feed meter, operating from a Venturi tube, was displayed by Simplex Valve & Meter Co., handling a stream of water from a small pump. Attention was called to the use in this meter of a specially shaped float known as the Ledoux float, the inside of which has a cross-section laid out on the square root curve; on account of the relations of the quantities involved, the motion of this float is directly proportional to the floor. This makes it possible to have uniform scale divisions in the meter and eliminates the need for mechanical multiplying devices.

The Yarway-Lea V-notch meter in a full size model was in operation at the booth of Yarnall-Waring Co., with the mechanism exposed to show the recording and integrating action.

The Bristol Co. showed its high speed attachment for recording meters to produce a drawn out record during abnormal conditions in the circuit served by the meter. Flush type recorders for all services were mounted on panels together with indicators to match them.

The Bristol-Derr water level gage for steam boilers operating on the thermo-electric principle was displayed. A newly developed electric clock, driven by a synchronous motor, was shown on several of the recorders. The Bristol Co. also furnishes a thermo-couple for measuring Diesel engine exhaust temperatures.

The Foxboro Co., Inc., had an attractive exhibit of instruments on a board showing flush type meters of all kinds for the coal-burning plant and emphasizing the new chart holder. The latter has a spring base and a tension head and is designed for quick operation and secure holding of the chart. Two instruments showed the difference between the gages manufactured in 1908 and in 1925.

Apex CO_2 instruments, both recording and indicating, were exhibited by Uehling Instrument Co., together with the new Uehling Waste Meter. The latter is a combination of recording pyrometer and CO_2 meters. Chemical solutions are not employed, the CO_2 being absorbed in a removable and renewable cartridge and the Pyro-Porus filter is provided to keep the gas lines clean.

Bearings, Reduction Gears and Mechanical Drives

The new Texrope drive for short centers was shown in operation at the booth of Allis-Chalmers Co., on a Bayley Mfg. Co. fan, driven through this Texrope drive by an Allis-Chalmers roller bearing motor. There was also shown a 40-hp. Texrope drive for an air compressor, the motor sheave being 12¾ in. in diameter at 860 r.p.m., and driving a 61-in. compressor sheave at 180 r.p.m., distance between centers being 54 in.

The Timken Roller Bearing Co. showed a miniature reproduction of its steel mill, including electric furnaces, 35-in. blooming mill, 22-in. bar mill, piercing mill and 10-in. merchant mill. By this means were shown the various steps in the manufacture of Timken roller bearings. The improved Timken bearing was also shown and demonstrated. This has the large end of the roll at right angles to the center line of the roll and has the rib of the cone slightly undercut so that contact with the large end of the roll is in two areas, giving perfect axial alinement and line contact between surfaces of roll and cone. The cage serves only to maintain proper spacing of rolls about the cone, since the rolls are self-alining.

Interest was shown in the worm gear reduction units of the Cleveland Worm & Gear Co. Specimens of the AT reduction unit, equipped with Timken bearings, were shown and the type AH for overhung load.

Fast's Flexible Couplings made by The Bartlett Hayward Co. were also exhibited. These couplings consist of 2 hubs, pressed and keyed to the respective shafts, each hub carrying an external spur gear. A floating sleeve carrying internal spur gears at each end surrounds the 2 hubs. The gear teeth of the sleeve engage the gear teeth of each hub and shafts and sleeve revolve as one unit.

At the booth of Joseph Dixon Crucible Co., a shaft carrying four ball bearings was shown, the bearings being equipped with brakes and spring balances to show the drag with various lubricants. Two of the bearings were lubricated with Dixon's graphite grease, the other two with unknown greases. Thermometers showed the temperatures of the lubricants and the drag on each bearing, all running under the same conditions of speed, pressure and lubrication, was measured by the spring balances.

Boston Gear Works Sales Co. featured the Lewellen variable speed transmission for various types of industrial machinery. A working motor-driven model of this was in operation showing the ball bearings, Boston silent-chain drives, remote control of speeds by push-buttons and electric tachometer.

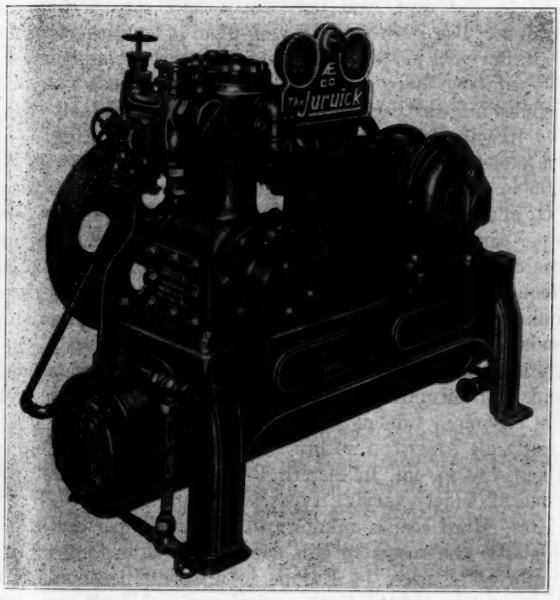
An 80-hp., two-cylinder Type Y Fairbanks Morse Diesel engine was also displayed. This was of the 2-cycle, valveless, solid injection type. Glass plates were fitted in crank case, permitting inspection of the rugged construction of connecting rods and crankshaft. A window was also provided in the governor compartment to show the action of the governor cams.

The Phillips coal spout swinger was exhibited by Henry Pratt Co. This device is used to swing the coal spouts across the hoppers of stokers and is provided in models for chain grate and underfeed stokers. It consists essentially of a chain running across sprockets at the ends of the hoppers and one or two shuttles driven from this chain. The shuttles are driven by sprocket wheels

Photographs of the exhibits used to illustrate this article were made by Kaufmann & Fabry, Chicago.

New Refrigerating Unit for Automatic Operation

AS AN addition to the Juruick line, an improved, self-contained refrigerating unit has recently been announced. This unit, especially designed for automatic operation, includes a motor, compressor, condenser and ammonia storage tank compactly mounted on one base and provided with all necessary controls. The machine is intended for use in markets, dairies, bottling establishments, small ice cream factories and other industries requiring a small automatic unit. The unit shown in the accompanying illustration is of 2-t. capacity; it will go through an ordinary door and can be located on any reasonably level floor without special foundations. Overall dimensions are:



THIS 2-T. REFRIGERATING UNIT, FOR AUTOMATIC OPERATION, USES AMMONIA AS REFRIGERANT

length, 68 in.; width, 24½ in.; height, 45½ in. It weighs about 1550 lb.

This compressor is built with the water jacket cast integrally with the cylinder to prevent water leakage and the jacket is designed with ample capacity to cool the cylinder with a minimum of water. A-E Co. metallic packing is used in the stuffing box; this consists of metallic rings and a ring of soft material. Each metallic ring has a spongy, oil-absorbing core, and is so constructed that it acts as a lubrication reservoir and oil seal against gas leakage. A bypass valve makes it unnecessary to start against compression and prevents belt slippage and overloads on the motor in starting.

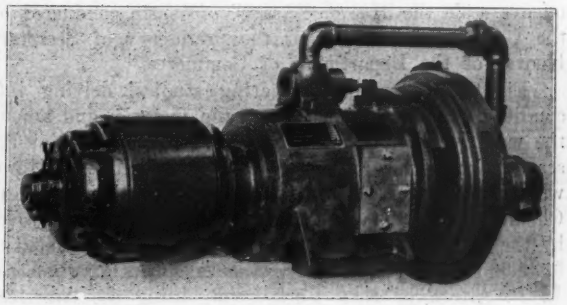
Depending on conditions, 3- to 5-hp. a.c. or d.c. motor is used, driving the compressor by a belt running over an idler mounted on roller bearings. The condenser is of the shell tube type and is arranged so that it can be easily cleaned of scale and sediment.

With this new unit, the entire process of refrigeration is controlled by a snap switch. A turn of the switch sets the machine for automatic operation but the unit can be operated by hand if desired. Protective devices and automatic control devices include an automatic starting box, with device for cutting off the current in case of overload; thermostat for starting and stopping the machine as cooling conditions require; automatic water regulator operated by the ammonia pressure to control and conserve the flow of water through the condenser; low water safety stop, which automatically stops the machine in case of inadequate supply of condensing water and starts it again when normal flow is resumed; high pressure stop to shut off the current from the motor in case the ammonia pressure mounts too high for any reason.

This new Juruick refrigerating unit is manufactured by the American Engineering Co., Philadelphia, Pa.

Small Automatic Emergency Light Unit

ARRANGED FOR use as an emergency light unit for the power station, the set starting automatically when for any reason the regular light supply in the station momentarily fails, a turbo-generator set in sizes from ½ to



SMALL EMERGENCY LIGHTING UNIT STARTS AUTOMATICALLY

10 kw. is now being manufactured by the Standard Turbine Corp., Scio, N. Y. Automatic starting is accomplished by a patented electric relay operating a shut-off valve in the turbine steam line.

Construction of this turbo-generator, shown in the accompanying illustration, is similar in every respect to the regular turbo-generator built by the company for oil field light sets and generators used for boats, magnet cranes, barges, and the like. It is characterized principally, by its large, stable governor, around which the whole set is designed. This governor operates in the oil space of the bearing pedestal and is thus assured of constant lubrication. Blading and nozzles are designed to be non-corrosive and non-erosive and the generator is made an integral part of the unit.

American Engineering Council Officers Elected

DEAN DEXTER S. KIMBALL of Cornell University was elected president of the American Engineering Council at the annual meeting of the Council at the Mayflower Hotel in Washington, January 13 to 15. Dean Kimball, past president of the American Society of Mechanical Engineers, succeeds former Governor James Hartness of Vermont.

Gardner S. Williams of Ann Arbor, Mich., and Irving E. Moultrop of Boston were named vice-presidents, Mr. Williams being re-elected. Dr. Harrison E. Howe of

Washington was re-elected treasurer, and Lawrence W. Wallace of Washington was again chosen executive secretary, a post he has held since the organization of the Council.

The Council at its Washington meeting approved a public works bill to be introduced in the Senate by Wesley L. Jones of Washington and in the House by Adam M. Wyant of Pennsylvania. This measure, adopted by a National Public Works Conference held on January 14 under the auspices of the Council, and attended by delegates from more than seventy national and local organizations, would change the name of the Department of the Interior to the Department of Public Works and Domain. Four assistant secretaries are provided for, and numerous transfers to the new Department of boards, bureaus, commissions and officers are made.

Plans for an organized attack on the problems of industry and agriculture, aiming to wipe out waste and to forestall possible economic disaster through dwindling labor supplies and crippled production, were framed.

Five years would be required to carry out this program of research, continuing on a unique and more extensive scale the Hoover "Assay" of Waste conducted by the Council in 1921 under the presidency of Secretary Hoover of the Department of Commerce.

Eight nationwide engineering studies, delving into conditions on the nation's farms and factories and among the workers, were proposed in a report of a Special Research Committee of the Council, of which Dr. Howe, who is editor of the official journal of the American Chemical Society, is chairman. This report was approved by the Council. The cost of the research is estimated at $335,000 by the Committee, other members of which are L. P. Alford of New York, representing the American Society of Mechanical Engineers; E. S. Coudrick, New York, Society of Industrial Engineers; Ray M. Hudson, Chief of the Division of Simplified Practice, Department of Commerce, and Lawrence W. Wallace of Washington.

Domestic Fuels Discussed

FUELS, and methods of firing for small house-heating boilers were discussed at a meeting arranged by the Fuels Division, Metropolitan Section, A. S. M. E., held in New York on Jan. 18. Particular attention was given to the handling of coke and bituminous coals, which have only now been brought into popular use in the East as a result of the anthracite miners' strike. The meeting was held jointly with the A. S. H. V. E., and several widely known combustion engineers contributed papers or discussion.

Henry Kreisinger discussed the burning of substitutes for anthracite coal. Any type of coke, he said, makes an excellent domestic fuel. Like anthracite it is a clean smokeless fuel, which will hold fire well, will give an even steady heat and require little attention. Because of its low volatile content it is also the best adapted for use in a furnace originally designed for hard coal. Being made from any bituminous coal, it is far more widely available, and cheaper even in non-strike years. Its ash is by volume only ½ to ⅓ that of anthracite. But the coke itself is bulkier by about a half; hence less can be stored and furnaces must be tended somewhat more frequently.

Bituminous coals, especially the caking coals of the eastern states, have the same advantages for domestic use that they have for power steaming. They are the most concentrated of any solid source of heat, Pocahontas and New River coals running 14,000 to 14,800 B.t.u. per pound, and Pittsburgh coal about 13,500, as against 10,500 for anthracite. They are also at all times much cheaper, and the objections to them are only the dirt and smoke which they may cause. But with proper handling coals like Pocahontas are practically smokeless, and on better acquaintance the prejudice against using any sort of soft coal should disappear in the East as it did long ago in other parts of the country where hard coal is almost unknown.

Tests conducted by Mr. Kreisinger for the Bureau of Mines at its Pittsburgh Station showed efficiencies lying between 60 per cent and 70 per cent for ordinary types of boilers when burning either anthracite or coke. The figure varied little over a wide range of rating. Using Illinois free-burning coal, the best efficiencies did not exceed 50 per cent, and only about half rating could be attained. The high-volatile long-flaming characteristic of the latter coal made it impossible to burn it completely in the ordinary short pass boiler. Pittsburgh coal gave efficiencies midway between the anthracite and Illinois coals, and like the latter were somewhat limited in rating. The draft observed in these tests was slight, about 0.02 in. to 0.05 in. in most cases. When burning anthracite or coke, CO_2 analyses showed 6 or 7 percent. CO content was 4 or 5 per cent for these cases. The ordinary domestic furnace was criticized as having too small a fire box, necessitating frequent firing, and a too short pass for the burned gases, making it impossible to get good results with high volatile coals.

Francis R. Wadleigh, discussing Eastern bituminous and semi-bituminous coals, used statistics to emphasize the economic side of the domestic coal situation. Practically all American anthracite is produced in a region of about 430 sq. mi. in eastern Pennsylvania, while bituminous of widely varying types is produced in 31 different states. Hard coal is unknown to perhaps 75 per cent of all domestic coal users in this country, as it is to the great majority of users in Europe. Anthracite is therefore a local problem of the Eastern Seaboard, while the so-called substitutes are the main source of house heating in the country generally. Also, soft coal is a more economic and reliable fuel, for its heating value is higher, the cost of production is less, and the industry is not liable to tieup by strikes. He predicted the gradual disappearance of anthracite as a domestic fuel, due in part to its growing scarcity.

In discussion it was said that one manufacturer is developing a boiler suited to use substitutes as well as anthracite. Most furnace builders until now have built only one type of boiler, a type fairly well suited to burn hard coal but not other fuels. Purchasers living in bituminous coal districts have had to pay the penalty of low efficiency due to inadequate design. Several builders are now giving attention to the correct design of these small units, and the next few years should see this backward branch of combustion engineering brought more nearly to a par with the present highly efficient generation of steam for power development.

THE RUSHVILLE WATER, Light & Power Co., Rushville, Ind., is installing a 1000-kw. Westinghouse turbine with surface condenser and spray pond and putting in Heine superheaters in their boilers. The work is being done under the direction of A. T. Mahin, superintendent of the plant, and Charles Brossman, of Indianapolis, Ind., is the consulting engineer.

P. R. Kolbe Installed as New President of Brooklyn Polytech

ON THE EVENING of January 13, 1926, Dr. Parke Rexford Kolbe was formally installed as the new president of the Polytechnic Institute of Brooklyn. The inauguration exercises were held in the Opera House of the Brooklyn Academy of Music and were attended by nearly 2000 people. In honor of Dr. Kolbe and in recognition of his work as an educator, more than 200 presidents and academic representatives of the leading colleges and universities of the country were present in full academic regalia, together with many representatives of scientific and learned societies.

On behalf of the Corporation of the Institute, William Henry Nichols, Vice-Chairman of the Corporation, delivered an address, Professor George Stuart Collins spoke for the faculty of the institution and Bancroft Gherardi of the class of 1891 for the alumni. Charles Alexander Richmond, President of Union College and Chancellor of Union University, spoke in behalf of the colleges. The presentation of the charter, keys and seal of the college was made by Charles Edwin Potts, Chairman of the Corporation, and this was followed immediately by the inaugural address of Dr. Kolbe.

News Notes

CELITE PRODUCTS CO. announces the removal of its Los Angeles offices from the Van Nuys Bldg. to 1320 So. Hope St.

THE DEARBORN CHEMICAL CO., of Chicago, Ill., announces that J. Biersdorfer has been transferred to Birmingham, Ala., with offices in the Martin Bldg., where he will represent the company in that district.

PITTSBURGH PIPING & EQUIPMENT CO., of Pittsburgh, Pa., has recently appointed G. Howard Boddy as district representative of the company with offices in the General Motors Bldg., Detroit, Mich.

THE TERRY STEAM TURBINE CO. announces the appointment of Fraser & Chalmers of Canada, Ltd., whose offices are in the Canada Cement Bldg., Montreal, as its sales representatives for the provinces of Quebec, Nova Scotia, New Brunswick and Ontario.

NEW YORK OFFICES have been opened by The Ric-wiL Co. of Cleveland, Ohio, in the Knickerbocker Bldg., with C. W. Lemmerman in charge. This office will give to contractors, architects, engineers and users in and around New York a more effective consulting and informational service than was previously offered by this company.

THE FOXBORO CO., INC., of Foxboro, Mass., has announced the change of address of its Pittsburgh office. Formerly located in the Park Bldg., the company has moved this office to what will now be known as the "Foxboro Building," on the corner of Sixth Ave. and Grant St. The four upper floors of the building will be utilized for offices and the maintenance of a substantial stock of new instrument equipment.

THE LOUISIANA ELECTRIC CO., Inc., a subsidiary of the Eastern Texas Electric Co. of Delaware, has authorized Stone & Webster, Inc., Boston, Mass., to proceed with the design and construction of a stepdown substation at Lake Charles and one at Jennings, La. The energy will be generated at the Nechez Power Station, Beaumont, Texas, which is at present under construction. The current will be stepped down from 66,000 v. to 33,000 and 2300 v. The Lake Charles substation will be located at the present power station. The Jennings substation will be on the outskirts of the town at some distance from the power station and the oil switches will be equipped with remote control mechanism.

ANNOUNCEMENT has been made by the National Electric Light Association that for the seventh time since its organization in 1885 its annual convention goes to Atlantic City. Preparations are being made by Association officers for an attendance of seven thousand people connected with the electrical industry, during the convention, May 17 to 23. With the completion of that convention, the 49th in the history of the Association, Atlantic City will hold the distinction of being the most favored city in the country as a convention center for the Association. The first convention of the National Electric Light Association was held at Chicago in Feb., 1885, with an attendance of 65 persons interested in furthering the art and science of electrical production and distribution. Since that time the Association has grown to a membership of over 15,000, representing electric light and power companies generating ninety per cent of the electricity produced in the United States, with the addition of many companies engaged in manufacturing electrical apparatus and others engaged in merchandising electrical appliances.

ANNOUNCEMENT IS made that the Sixth Annual Joint Convention of the Illinois State Electric Association, Illinois Gas Association and the Illinois Electric Railways Association will be held in Springfield, Ill., on Wednesday and Thursday, March 17 and 18. A program of statewide interest to all branches of the utility industry is being prepared. Plans are being made to hold joint morning sessions and separate afternoon sessions for each association. Entertainment will be provided on one evening and the other evening will be given over to an educational program. Both morning sessions will be held in Hotel Abraham Lincoln, while the afternoon sessions of the Electric Association will be held in St. Nicholas Hotel, those of the Gas Association in the Leland Hotel and those of the Railway Association in the Hotel Abraham Lincoln.

THE MONTAUP ELECTRIC CO., Somerset, Mass., having recently completed the initial installation at its Somerset Station, will double transmission facilities from Swansea Junction to Fall River and to Blackstone Junction. Another circuit will be required to Blackstone and a double circuit to Fall River. The Fall River connection will cross the Taunton River 150 ft. above high water for a distance of 1200 ft. The engineering work will be done by Stone & Webster, Inc., Boston, Mass.

A MOVEMENT has been started by the New England states, with the exception of Maine, to secure united effort on the part of the Public Utilities Commissions of all the states for correlation of laws pertaining to electric power transmission. Because of Maine's statutory prohibition of the export of power, Maine is not included although it is expected that at the next state election the prohibitory statute will be repealed. William C. Bliss, chairman of the Public Utilities Commission of Rhode Island, has been

named as that state's representative on the commission. It is understood that the New England states will work in cooperation with New York, New Jersey and Pennsylvania, which have already started a similar movement. The other states are expected to name their representatives within a short time.

Catalog Notes

FAIRBANKS-MORSE & Co. of Chicago has recently issued a bulletin entitled "Comparison of Diesel Engine Practices." This bulletin analyzes the various factors which influence the design of Diesel engines and interprets these factors in terms of what they mean to the Diesel engine user in overall operating economy, simplicity in operation, low upkeep expense, long life and dependability.

SEVENTY-FIVE Cent Dollar is the title of an address delivered by Shorland F. Fannon before students of the Mass. Inst. of Technology and which is being sent out in pamphlet form by the Sherman Service Inc., 31 Milk St., Boston, Mass. It presents the loss incurred from low production due to lack of interest of workers and discusses the need for a worker to have a motive to do his best and a plan for securing his interest and furnishing such a motive.

CENTRIFUGAL AIR COMPRESSORS of the single stage type are described in a bulletin recently received from General Electric Co., Schenectady, N. Y. These centrifugal compressors are supplied in sizes from 250 to 75,000 cu. ft. per min., the larger units being built for pressures as high as 35 lb. gage. They can be obtained either for motor or turbine drive. The bulletin shows all the details of construction and gives a curve of operating characteristics and various tables of ratings.

"ELECTRICAL DRIVES for Power Plant Auxiliaries" is the title of Motor Application circular No. 7381, recently issued by the Westinghouse Electric and Mfg. Co., E. Pittsburgh, Pa. This booklet, which consists of 24 pages, outlines briefly the advantages of electric drive for power plant auxiliaries and gives pointers of value in selecting motors to be used for driving and for charging auxiliaries. It is attractively illustrated with half-tones and contains considerable engineering information of value.

THE GRISCOM-RUSSELL Co., New York City, is distributing the fifth edition of a booklet entitled "Raw Water Distilling Plants for Producing Distilled Boiler Feed Make-Up Water." This booklet was prepared by Joseph Price and deals with the benefits secured by the use of pure boiler feed water, notes regarding distilling plants, power plant heat balance and heat benefit analysis. The booklet is well illustrated and may be classed as a textbook on the subject.

ALL-PURPOSE CRAWLER CRANES are treated in Book No. 895, just issued by Link-Belt Co., Chicago. The book contains 48 pages, generously illustrated to show the use of the drag-line, dipper and trench shovel, skimmer scoop, hook blocks and pile drivers. Data on lifting capacities, approximate operating speeds, line pull, tractive effort, etc., are given. The tables in which these data are arranged have been supplemented by line drawings which show dimensions for operating limits. Information is also given on some of the usual, as well as the more ingenious uses to which the various types of cranes can be put.

HAHN ENGINEERING Co., Philadelphia, Pa., has recently published a pamphlet on its ash and coal handling equipment.

BULLETIN No. 3, recently issued by The Walworth Company, Boston, Mass., is an interesting pamphlet dealing with thirty points of merit in Walworth sigma steel high pressure O. S. & Y. wedge gate valves.

TYPE D-54 MECHANICAL DRIVE TURBINE, intended for the driving of centrifugal pumps, blowers and other classes of mechanical drive, is described in Bulletin GEA-197, just issued by General Electric Co., Schenectady, N. Y. The turbine is described and a sectional view shown.

THE ESTERLINE-ANGUS Co. of Indianapolis, Ind., has issued as Bulletin No. 1225 a leaflet containing an article entitled "Use of Graphic Instruments in Setting Circuit Breakers and Overload Relays" by G. A. Garland, electrical engineer, Minnesota By-Products Coke Co., St. Paul, Minn.

W. S. ROCKWELL Co., 50 Church St., New York, has just issued a bulletin entitled "The Selection of Fuel for the Heat Treatment of Metal" which is prepared to give a better understanding of the fuel problem in industrial heating operations in metallurgical, ceramic and chemical industries.

IDEAL SWITCHBOARDS and synchronous motor starting panels are described in Bulletin No. 111 recently issued by The Ideal Electric & Manufacturing Co. of Mansfield, Ohio. The bulletin calls particular attention to the eight points of protection found on Ideal automatic synchronous motor starting panels.

W. D. CASHIN Co. of Boston, Mass., has recently issued its Bulletin No. 10 covering specialties for vacuum and vapor heating. The bulletin contains not only line drawings and halftones of the various types of valves and traps used in heating systems but also gives short descriptions and tables of dimensions.

PENNSYLVANIA CRUSHER Co., Liberty Trust Bldg., Philadelphia, has recently issued a loose-leaf folder containing photographs and bulletins dealing with Pennsylvania coal preparation machinery and the Pennsylvania Bradford breakers and their application to the problems of coal preparation for use in power plants.

"ARTIFICIAL ABRASIVES, Their History and Development" is the title of an interesting booklet recently issued by Norton Co., Worcester, Mass. Some of the subjects treated are the grindstone, emery or corundum, silicon, carbide, aluminous artificial abrasives, bauxite, qualities required in an abrasive, methods of varying physical properties, alundum and crystolon.

GENERAL ELECTRIC CATALOG 6001B, superseding all previous catalogs issued by the company, with the exception of those dealing with railway, mine and industrial supplies and merchandise products, is being distributed. The complete catalog is issued every two years. The book is 2 in. thick and contains more than 1100- 8 by 10½-in. pages. The illustrations total more than 3200. It is thumb-indexed into 16 sections as follows: Generation, wire and cable, distribution transformers, arresters, voltage regulators, switchboards and accessories, meters and instruments, motors, motor applications, industrial control, railway, lighting, industrial heating, miscellaneous, and indexes. In the indexes, products are classified both by subjects and by catalog numbers.